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JET STREAM CLIMATOLOGY

at 500 mb

NORTH of 50° N

U. S. NAVY WEATHER RESEARCH FACILITY
BUILDING R-48, U. S. NAVAL AIR STATION
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FOREWORD

Task 20, entitled "Jet Stream Investigation for Specified Areas," was assigned to BuAer Project AROWA by the Chief of the Bureau of Aeronautics in 1952. The purpose was to conduct a broad study of jet stream conditions over the Northern Hemisphere area north of 50° N.

Most of the work thus far has been done by the Pacific-Alaska Division of Pan American World Airways Inc. Messrs. Sidney M. Serebreny, Eldon J. Wiegman, and Rex G. Hadfield were the principal investigators; they prepared nine reports which, taken together, comprise a unique jet stream climatology of the Northern Hemisphere north of 50° N. The uniqueness lies in the fact that the 500 mb. surface has served as the key level in the study.

The Pan American and NWRF (AROWA) participants realized from the beginning that the core of the jet stream was well above the 500 mb. level, but more well-analyzed charts were available at 500 mb. than at any other level. Also, for several reasons, the future topography of the 500 mb. surface can be forecast more accurately than almost any other charted meteorological parameter. It seemed logical to devote a great deal of attention to high speed wind centrums at 500 mb. and to their relationship to both the jet stream winds above and the surface weather features below.

This report summarizes the several Pan American reports. It was prepared by Mr. Gene D. Prantner, Assistant Task Leader of Task 20.

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PREFACE

This report presents the results of a study of jet stream conditions on the Northern Hemisphere 500 mb. surface north of the 50th parallel during the ten years: January 1947 - December 1953, and January 1955 - December 1957.

For purposes of this investigation, jet streams were defined as organized regions of wind speed having a maximum in excess of 50 knots along the centrum (major axis of the isotach field).

The Daily Series Synoptic Weather Maps Northern Hemisphere Sea Level and 500 Mb. Charts [9] were utilized as principal source material since they provided the most complete and readily available backlog of data at the time that this study was initiated. In certain instances it became necessary to use maps of the National Weather Analysis Center, Washington, D. C. [5] and of the German Weather Service [3] as supplementary material.

In areas of sparce data, the evaluation necessarily was subjective insofar as the analyses were based on geostrophic considerations.

Chapter I of this report consists of a discussion of the frequency of occurrence of jet streams on a seasonal and monthly basis throughout the Northern Hemisphere north of 50°N. A climatological catalogue and discussion of the large scale jet stream patterns that are apparent when blocking conditions exist in specific geographic locations is presented as Chapter II.

The data, results and conclusions presented in this report are based primarily on 500 mb. data and hence should not be applied indiscriminantly to other constant pressure surfaces since, in general, the configuration, orientation, and magnitude of jet stream centrums at one atmospheric level does not necessarily define conditions at other levels.

1. A DISCUSSION OF JETSTREAM OCCURRENCES IN THE NORTHERN HEMISPHERE NORTH OF 50 DEGREES NORTH LATITUDE

1.1 Introduction

The primary objective of Chapter I of this report is to present a census of jet streams on the 500 mb. constant pressure surface within the latitudinal limits of 50°N and 85°N. The census was taken from 500 mb. constant pressure charts selected from alternate years of a ten year period beginning with December 1947, and ending with November 1957 with data for 1957 being substituted for those of 1954 for the months of March, April, and May. Jet stream centrums were entered on these charts (one map per day) and a tally of directional as well as total occurrence was taken in sectors bounded by 5 degrees of latitude and 10 degrees of longitude. Charts entitled Frequency of Occurrence and Orientation of Jet Stream Centrums at 500 Mb. are presented showing these data. A total of sixteen charts were prepared, one for each month as well as one for each season with the seasons delineated as follows: Winter (December, January, February); Spring (March, April, May); Summer (June, July, August); and Autumn (September, October, November). Only the seasonal charts are presented in this report since the monthly totals of jet stream occurrences were, in most instances, too small to serve adequately as a basis for drawing conclusions as to spatial and temporal variation of jet streams at 500 mb. In addition, all of the features of interest inherent in the monthly charts are found to some degree in the seasonal charts and for purposes of comparison, the season to season changes in jet stream location and orientation are much greater than the month to month changes. These charts were constructed by dividing the Northern Hemisphere from 50°N to 85°N into sectors having dimensions of 5 degrees of latitude by 10 degrees of longitude.

Within each sector a frequency rose was constructed with the total count entered in the center. The directional distribution was taken to eight points of the compass with the frequency being delineated by the length of the arrows. For accuracy the actual number was placed at the end of the arrow. In those cases where the length of the arrow extended beyond the limits of the sector, it was broken and the number of occurrences entered in the break.

In addition, various supplementary charts employing particular aspects of the frequency of occurrence of jet stream centrums on a spatial as well as seasonal basis are presented. These include: (1)

Histograms showing frequency of occurrence of jet stream centrums by latitude and longitude on a monthly basis as well as the total seasonal count in selected areas 10 degrees of longitude wide and extending from 50° N to 85° N; (2) Charts indicating the dominant direction of orientation of the jet stream centrums where by definition "dominant" represents a directional incidence equal to or greater than 30 percent of the cases within each sector. These charts were prepared on a seasonal basis only; (3) Charts showing isopleths of frequency of occurrence of jet stream centrums are shown for each season since it is felt that such a presentation is valuable in visualizing and comparing the gradients of increase or decrease in incidence and areas of maxima and minima. It should perhaps be noted that the isopleths were drawn by assuming that all the jet stream centrums occurring within any particular sector were assumed to have occurred at the center of the sector.

1.2 Seasonal Considerations

1.2.1 Winter

In figure 1.1 is shown the total number of jet stream centrums at

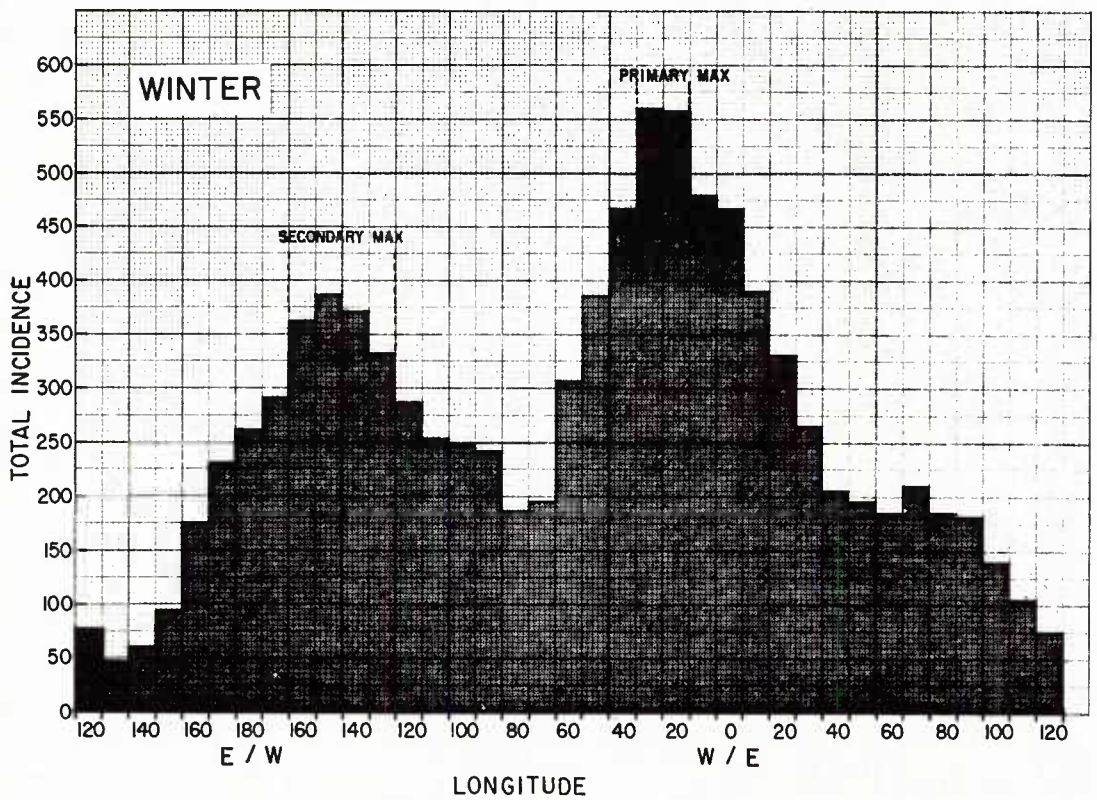

Figure 1.1. Total Incidence of Jet Stream Centrums in 10 Degree Sectors of Longitude Summed over Latitudes 50°N. - 85°N. for Winter.

500 mb. occurring during winter in each 10 degree sector of longitude within the latitudinal limits of 50°N to 85°N in the 5 years of data used in this investigation. Two regions of maximum incidence are evident. They are bounded by the longitudes of 15° W and 35° W (primary maximum) and 125° W - 165° W (secondary maximum).

It is apparent from figure 1.2 that both regions of maximum frequency are characterized by a change in jet stream orientation from southwest flow to northwest flow, i.e., by a large scale ridge. Note that

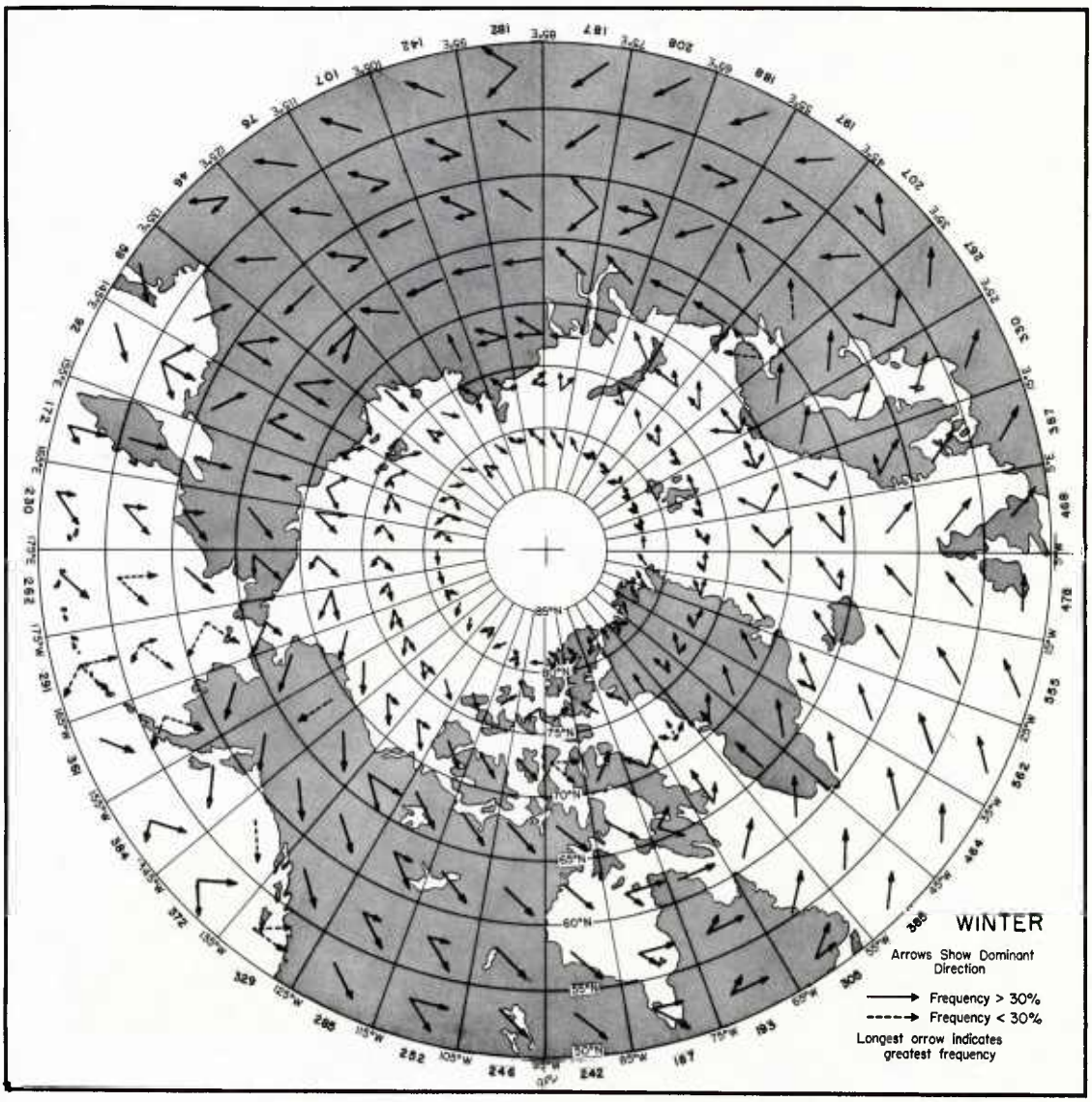

Figure 1.2. Dominant Orientation of Jet Stream Centrums for Winter.

the total occurrence from 50° N to 85° N bounded by any two longitudes is entered along the outer periphery of the figure. In the region of the primary maximum (15° W - 35° W) the change in orientation occurs downstream from the longitude of maximum incidence. The predominant direction of the jet stream axis is southwesterly over most of the region of maximum incidence.

In the region of the secondary maximum (125° W to 165° W) the shift from southwesterly to northwesterly direction lies upstream from the center line of maximum incidence; in this case, however, the predominant jet stream orientation in the region of maximum incidence is from the northwest.

A third ridge line is observed between 85° E to 65° E longitude. While the incidence in this region is materially less than in either of the aforementioned maximum regions, it does reflect the fact that well developed ridges (even blocks) are found in this area. The catalogue in Chapter II includes two blocking types that are found in this region.

The apparent absence of jet stream incidence in the area bounded by 105°E and 150°E is influenced by the usual lack of data in this area and the resulting tendency to construct a rather symmetrical and evenly-spaced contour analysis. In most instances the resulting gradient does not reflect jet stream conditions. However, since this is the favored region of the mean trough at 500 mb. in the Western Pacific - Eastern Siberia region, (fig. 1.3) it is felt that the small incidence in these latitudes is truly representative--qualitatively if not quantitatively--and that the jet stream is normally well south of 50°N in this region.

It is interesting to compare various features of figures 1.1 and 1.2 with figure 1.3. The bi-modal distribution of jet stream incidence (centered near 25°W and 140°W) agrees to some extent with distribution of the mean ridges. These areas are also favored regions for the presence of blocks [8]. The region of minimum frequency (centered near 135°E and 75°W) also nearly coincides with the location of the troughs, reflecting the fact that jet streams are deflected south of 50°N in these areas. In addition, the dominant winter jet stream orientations parallel the mean winter flow pattern quite well - particularly where the incidence is equal to or greater than 40 cases.

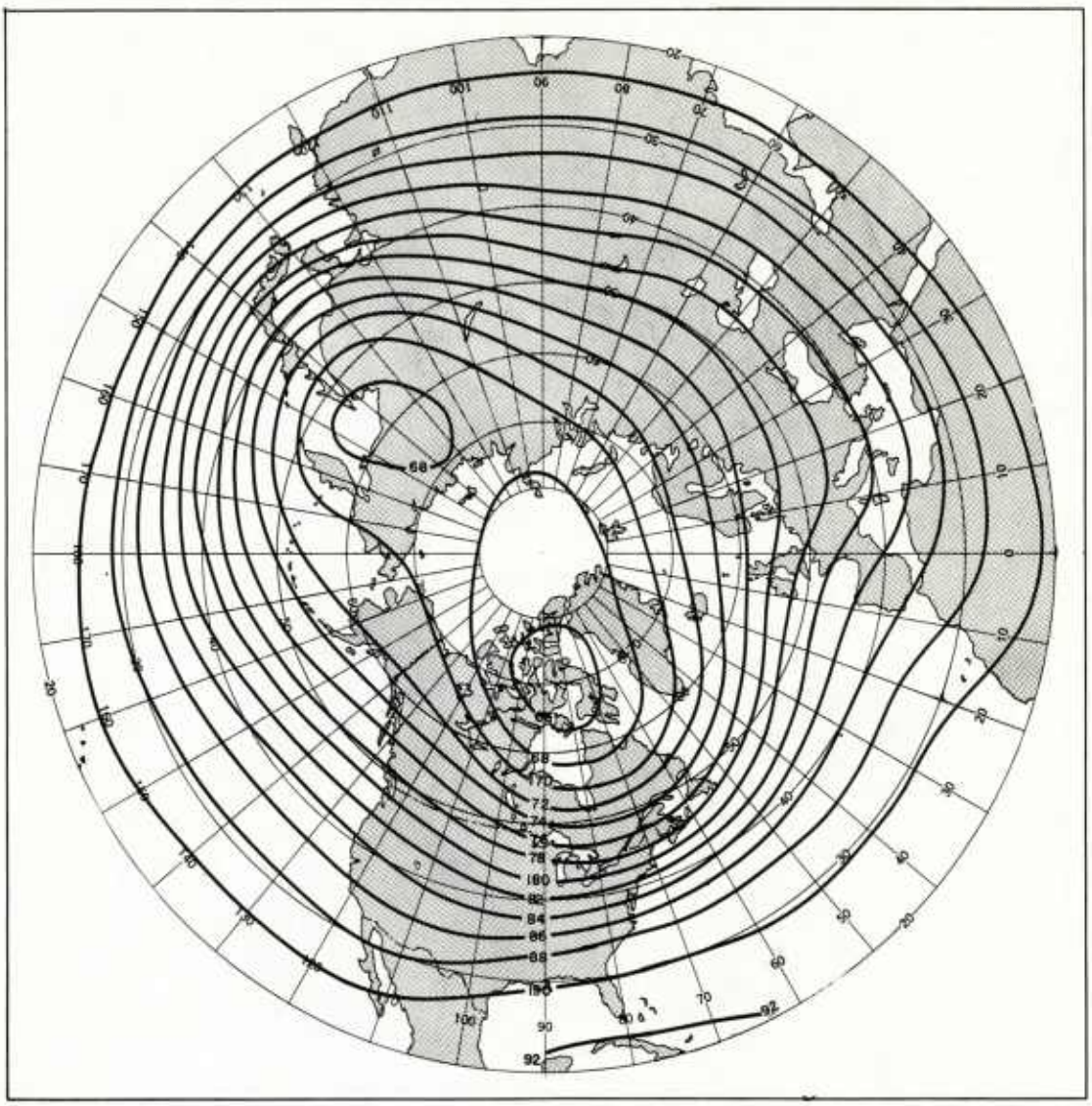

Figure 1.3. Winter Mean 500 Mb. Chart. Heights Are Given in Hundreds of Feet.

Figure 1.4 shows the frequency and direction of jet stream centrums at 500 mb. during the winter season by individual sectors of 5 degrees latitude by 10 degrees longitude. A chart showing isopleths of total occurrence of jet stream centrums by individual sectors (fig. 1.5) is included as an aid in interpretation of these data.

A feature of note is the eastward displacement of the primary

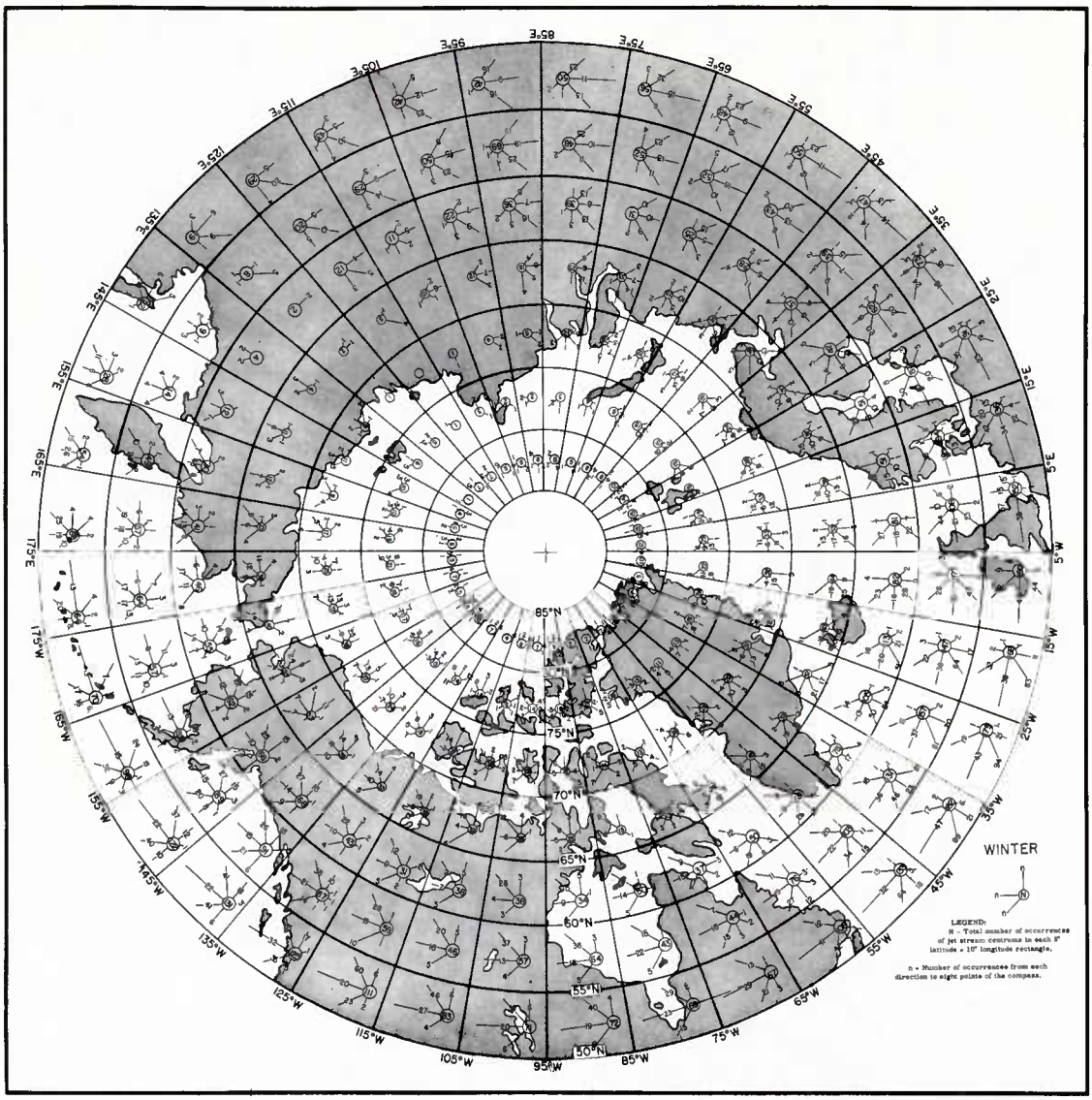

Figure 1.4. Frequency and Direction of Jet Stream Centrums for Winter.

maximum and the westward displacement of the secondary maximum with increase of latitude. The primary maximum between latitudes 50°N and 55°N is bounded by the longitudes 35°W - 45°W while between 80°N and 85°N it is bounded by the longitudes 15°E and 25°E. The secondary maximum between latitudes 50°N and 55°N is bounded by the longitudes of 145°W and 135°W whereas between latitudes 70°N and 75°N it is bounded by the longitudes of 155°W and 165°W. The degree to which

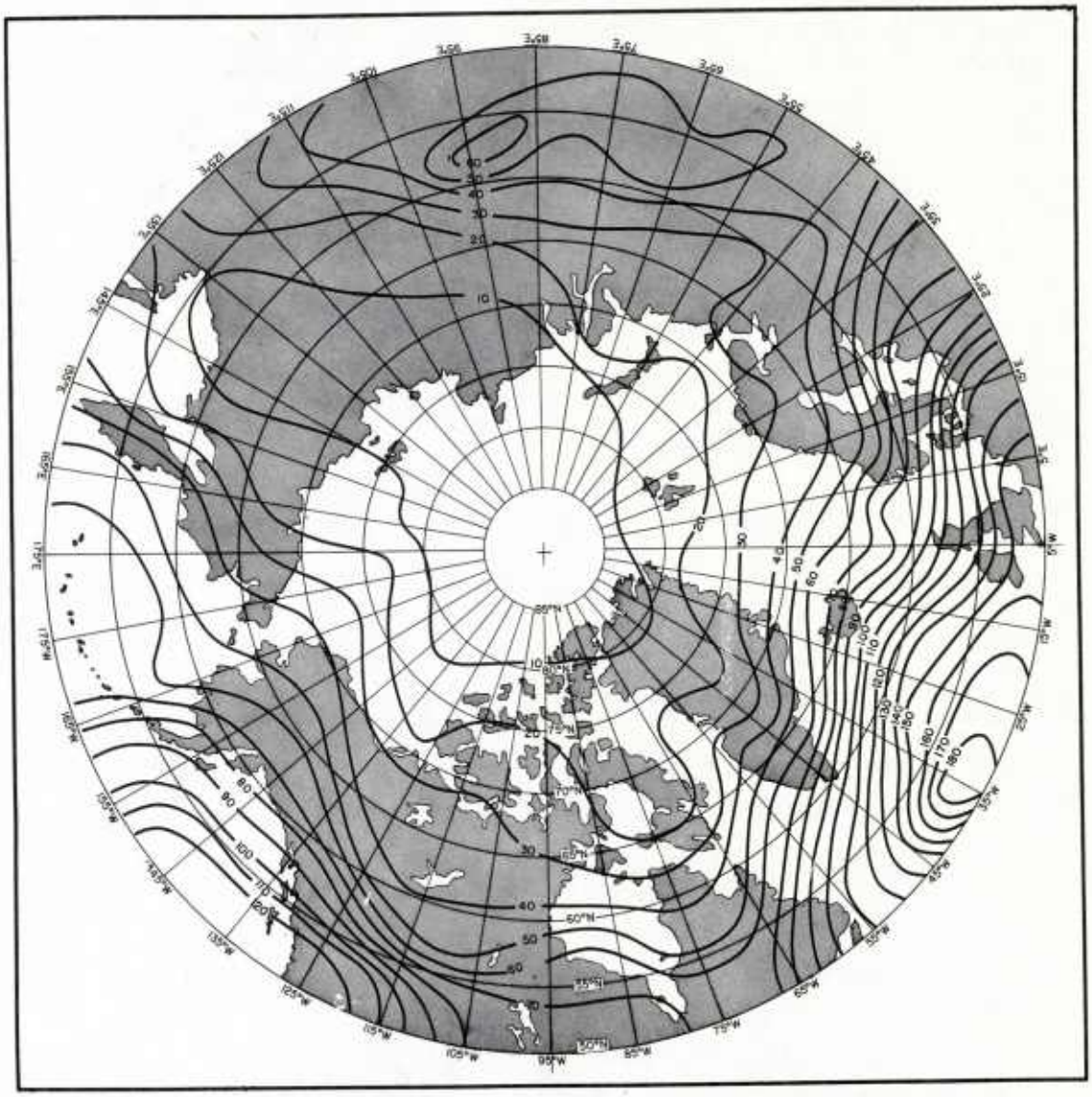

Figure 1.5. Isopleths of Total Incidence of Jet Stream Centrums for Winter. (From data in fig. 1.4.)

these displacements are influenced by the distribution of reported data, by the eccentricity of major pressure systems, or by subjectivity of analysis is beyond the scope of this report. Suffice it to say that the reader should certainly keep these factors in mind when applying the results of this study to operational problems.

Up to this point the discussion has been in terms of the entire

winter season. Figure 1.6 shows the distribution of jet stream centrums around the Northern Hemisphere for the individual months of December, January, and February. The distribution remains bi-modal from month to month, varying only in degree up to 70°N. Above 70°N the incidence of jet stream centrums, in all months diminishes rather rapidly. The bi-modal tendency also disappears at these high latitudes, indicating that, either the influence of ridges and blocks upon the jet stream does not often extend beyond 70°N - except in isolated instances - or merely that lack of data at high latitudes results in an overly smoothed analysis that masks out wind maxima. In general there is no significant difference in the incidence pattern from month to month and each individual month, to some degree, contains all the significant features of the winter mean.

1.2.2 Spring

In spring the primary longitudinal area of maximum incidence of

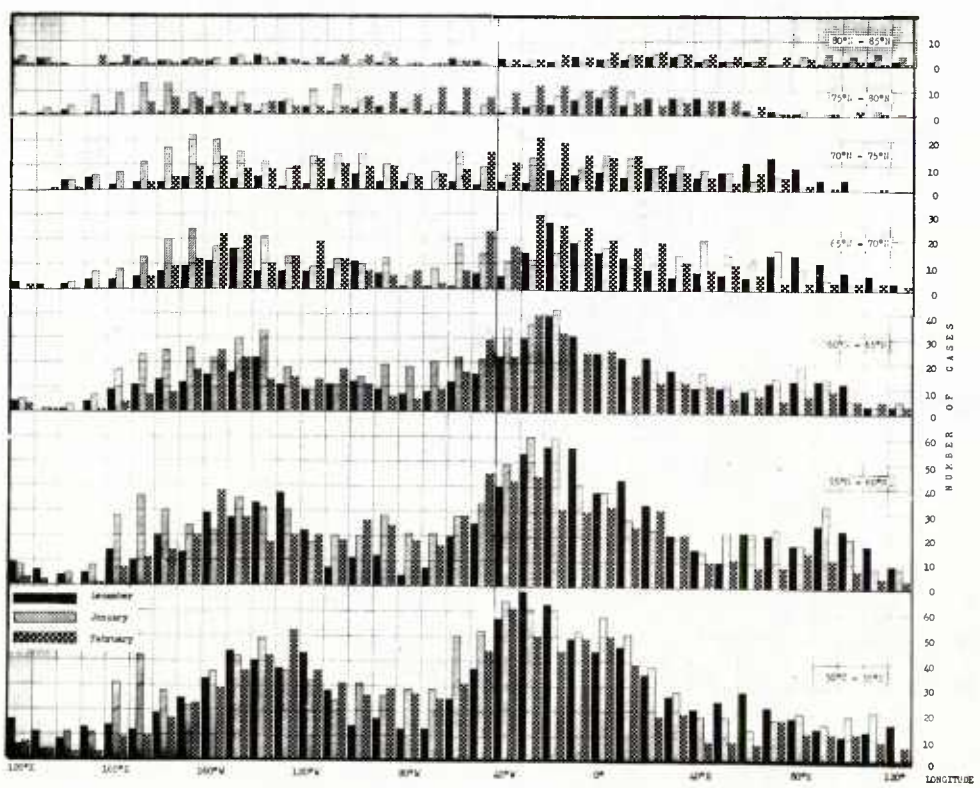

Figure 1.6. Total Incidence by Latitude Band and Month of Jet Stream Centrums for Winter for Five Year Period.

jet stream centrums is centered about 20°W, with secondary maxima at 70°E, 155°W, and 100°W as seen in figure 1.7.

The secondary total maximum at about 70°E represents an interruption or "plateau" in the trend of diminishing incidence downstream from the region of primary maximum. This "plateau" extends from 40°E to 80°E. The dominant directions, as indicated in figure 1.8, are from the northwest and southwest reflecting the influence of both ridges and lows in the Black Sea area immediately upstream. Further downstream the maximum jet stream incidence apparently shifts south of 50°N in association with a pronounced intensification of cyclone activity between 60° and 65°N during this season.

Another secondary maximum of jet stream incidence is found in the region between 165°W and 145°W. The variation of dominant directions, especially in the higher latitudes, indicates that a wide variety of synoptic patterns may occur in this area during this season.

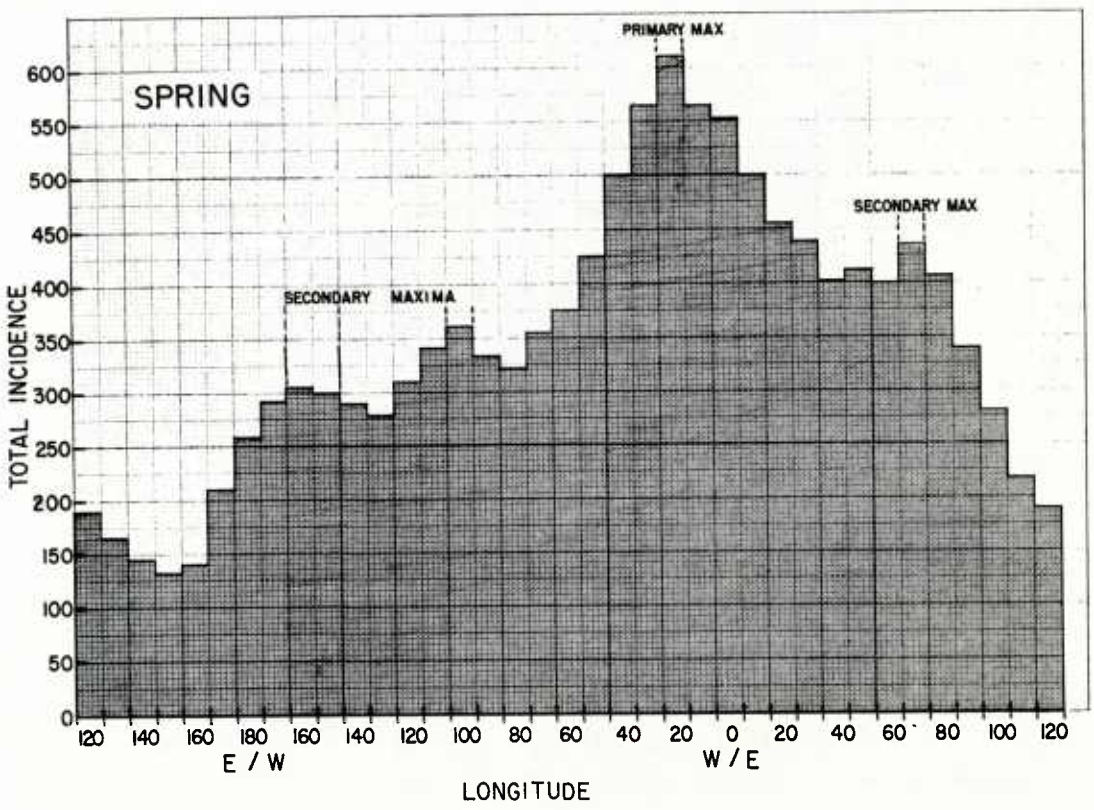

Figure 1.7. Total Incidence of Jet Stream Centrums in 10 Degree Sectors of Longitude Summed over Latitudes 50°N. - 85°N. for Spring.

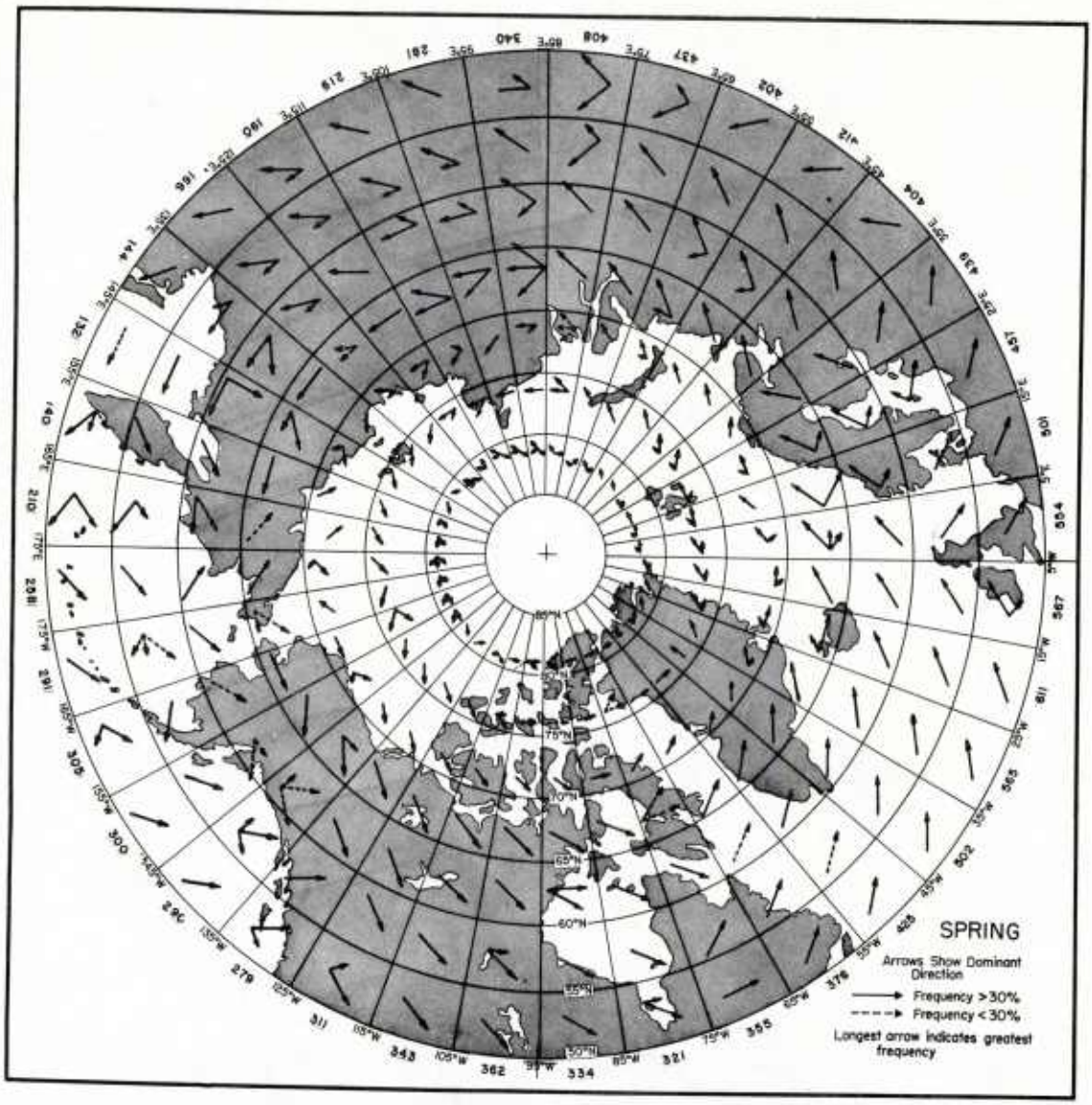

Figure 1.8. Dominant Orientation of Jet Stream Centrums for Spring.

The secondary maximum centered at 100°W lies between the position of the mean ridge at 130°W and the mean trough at 75°W, as shown in figure 1.9. It reflects both the presence of polar outbreaks from Canada as well as the intrusion of frontal systems from the Pacific. The true maximum of incidence along the longitude is somewhat south of the 50th parallel.

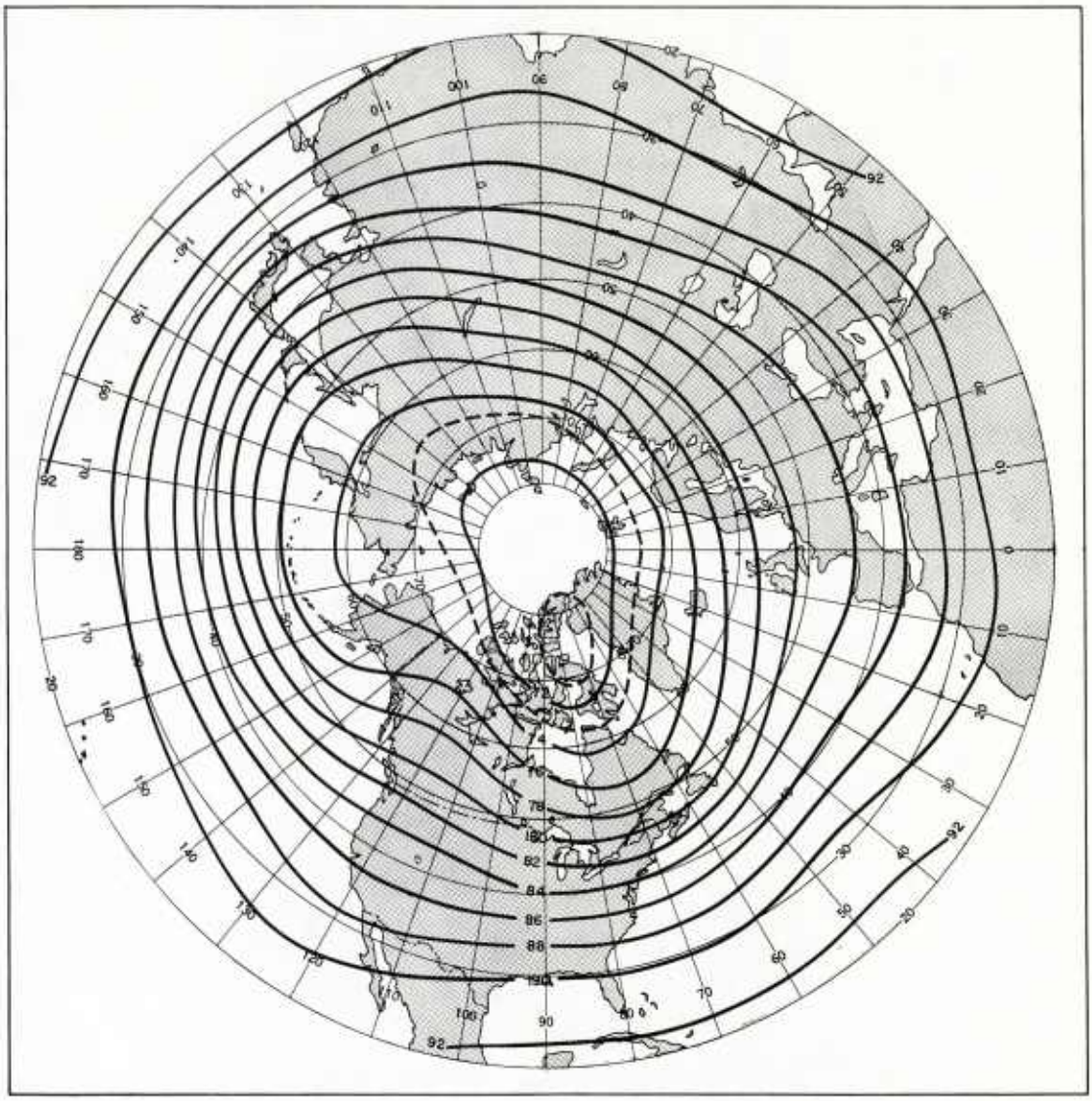

Figure 1.9. Spring Mean 500 Mb. Chart. Heights Are Given in Hundreds of Feet.

The orientations of the jet stream centrums both upstream and downstream from the major trough on the 500 mb mean chart (figs. 1.8, 1.9) closely parallel the contours.

Examining the distribution of jet stream centrums by individual sectors (5 degrees of latitude by 10 degrees of longitude, fig. 1.10), it is seen that the primary maximum near 25°W is displaced eastward

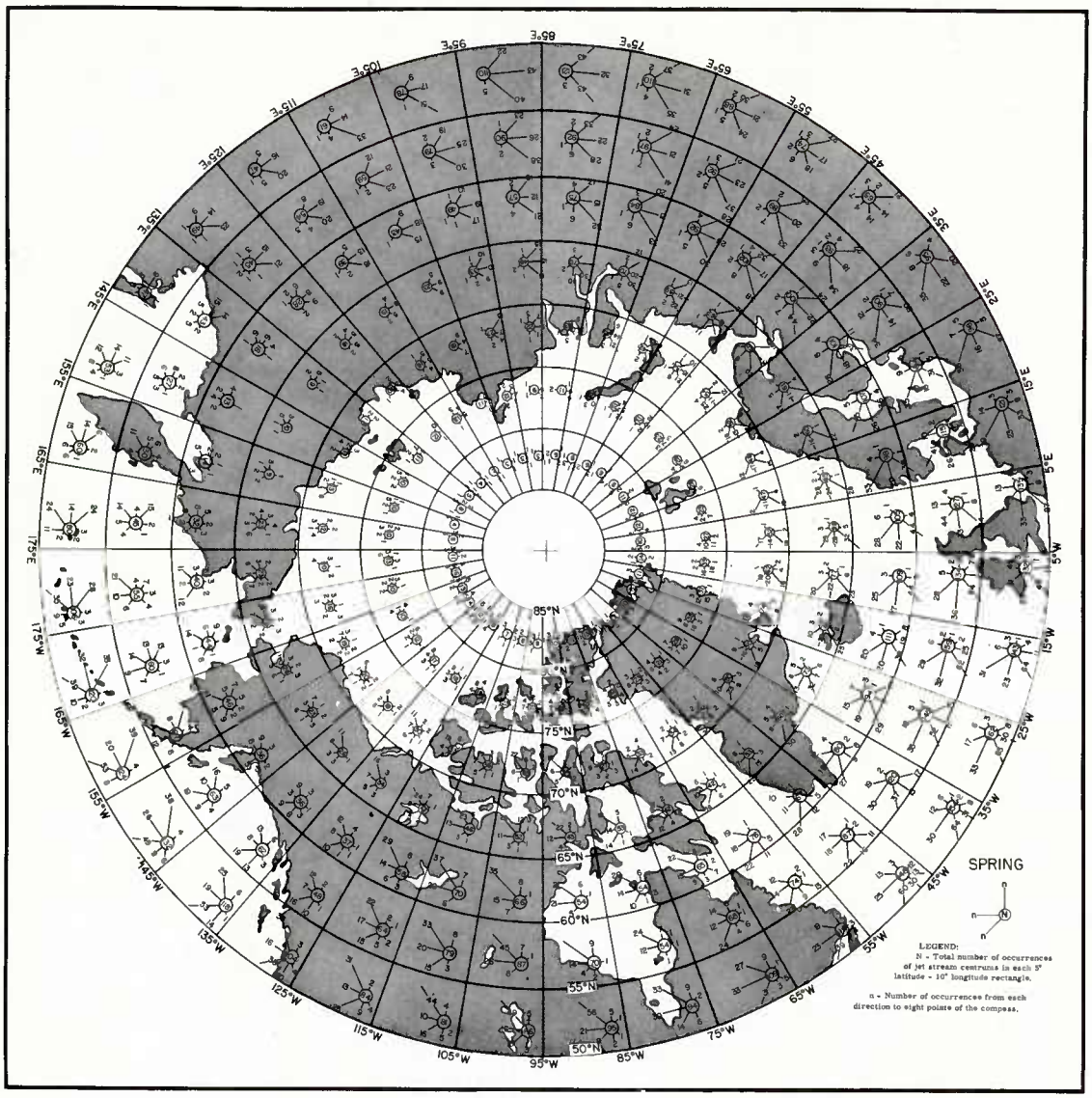

Figure 1.10. Frequency and Direction of Jet Stream Centrums for Spring.

with increasing latitude up to the 70th parallel. Above this latitude the slope is reversed but the maxima within the latitude rings are not strongly marked. Upstream from this line of maxima the dominant orientations are southwesterly as far as 65°W (fig. 1.8). Downstream from the line of maximum incidence the orientations for the most part are bi-directional (west and southwest) except for the area 5°W to 35°E (50°N to 60°N) where the orientations are northwest.

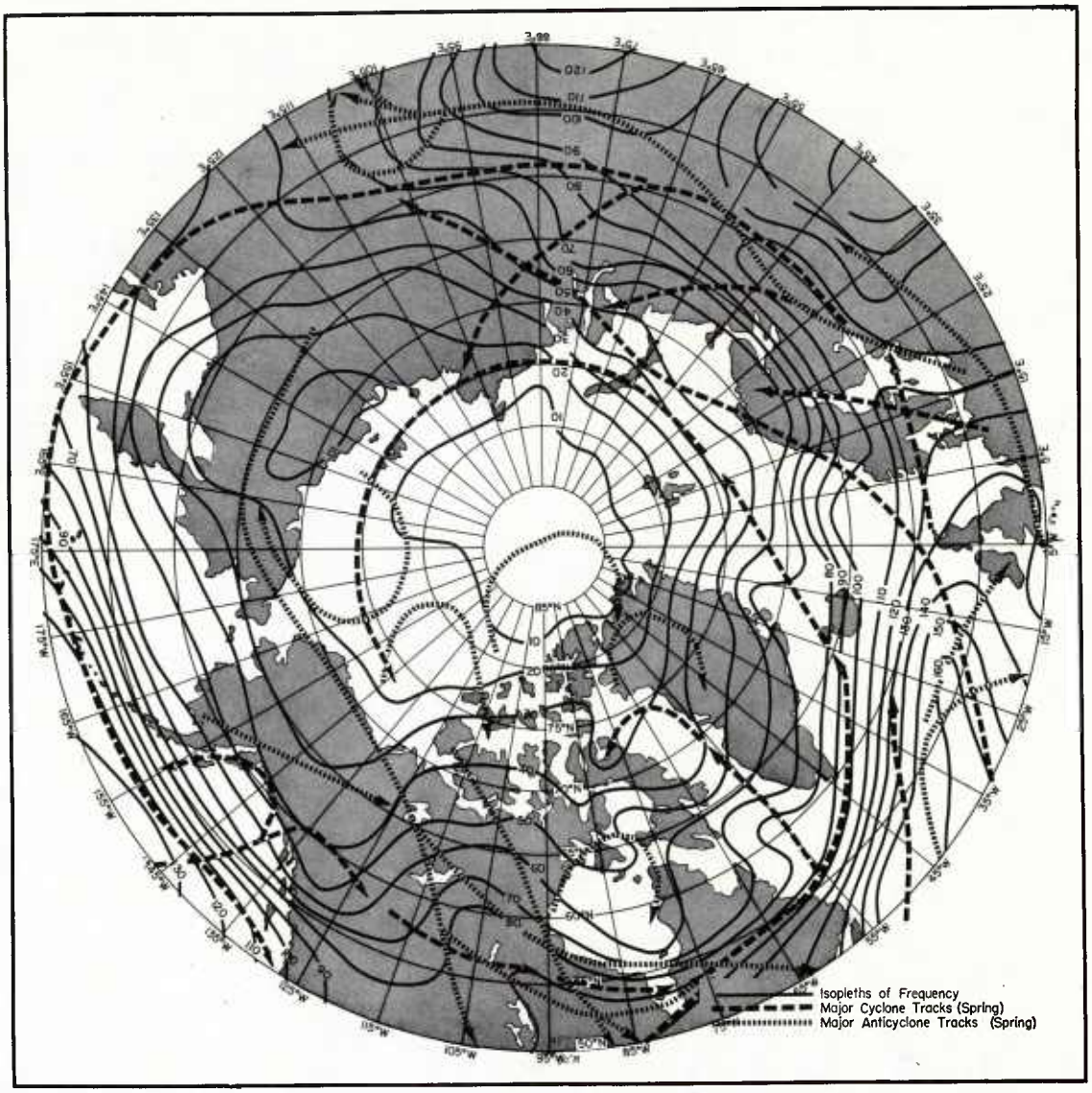

Figure 1.11. Isopleths of Total Incidence of Jet Stream Centrums for Spring. (From data in fig. 1.10.)

In figure 1.11, isopleths of frequency from data in figure 1.10 are superimposed on the major cyclone and anticyclone tracks in the Northern Hemisphere as presented by Berry, Owens, and Wilson [1]. Table 1.1 shows the cyclone-crossing frequencies at various longitudes as reported by the same authors.

In the region of the primary maximum (summed over all latitudes

TABLE 1.1
Cyclone-crossing Frequencies at Various Longitudes

Latitude	(a) 15°W				(b) 25°E				(c) 95°E				(d) 145°E			
	W	S	S	F	W	S	S	F	W	S	S	F	W	S	S	F
85 - 80	9	11	26	12	32	15	30	22	48	32	39	43	37	34	29	36
80 - 75	38	34	28	33	66	51	33	66	78	72	56	72	42	49	34	46
75 - 70	70	56	32	58	75	72	39	65	75	66	55	67	33	46	54	45
70 - 65	78	54	47	63	43	59	49	47	51	60	66	67	22	44	65	28
65 - 60	93	65	75	93	44	58	52	42	46	73	80	50	10	42	53	31
60 - 55	84	57	79	80	47	51	49	31	27	44	44	43	36	53	48	51
55 - 50	54	53	59	59	46	27	28	21	12	13	23	9	52	81	59	88

Latitude	(e) 175°W				(f) 95°W				(g) 55°W			
	W	S	S	F	W	S	S	F	W	S	S	F
85 - 80	5	18	18	18	4	12	40	12				
80 - 75	18	19	30	33	24	22	33	29				
75 - 70	26	31	44	48	27	20	46	43	65	39	48	50
70 - 65	28	17	65	35	29	30	37	41	62	52	63	66
65 - 60	52	40	69	45	50	44	61	75	86	58	69	89
60 - 55	80	73	84	75	52	39	71	79	86	89	103	98
55 - 50	112	109	86	99	66	71	96	85	107	94	109	91

north of 50°N), 25°W to 15°W, the greatest incidence of frequency is contained within the latitude band 50°N to 60°N. This distribution agrees quite well with the maximum occurrence of the major cyclone tracks between 60°N - 65°N (see table 1.1a). Downstream, at longitude 40°E, the greatest frequency in jet stream count lies between 60°N and 65°N during this season, also in agreement with major cyclone tracks (fig. 1.11).

There is another major cyclone track at high latitudes in this region but it is not accompanied by an increase in jet streams in these latitudes probably due in part to lack of necessary analyzed gradient and/or absence of data.

In the area of the major trough (75°W) the greatest incidence of jet streams is found south of the 55th parallel similar to the situation at 125°E to 145°E though not to the same degree. From 155°W to 125°W the incidence of jet streams reaches a maximum between 50°N - 55°N in association with the northward penetration of the major cyclone tracks (see table 1.1e). The much higher frequency near 55°N than at higher latitudes illustrates the degree to which the tracks tend to remain south of 55°N.

At 125°W a marked poleward relaxation in the gradient of incidence is evident (see fig. 1.11) just upstream from an area of secondary maximum. In the high latitudes between 125°W and 75°W, the increased jet stream incidence is found in the area where strong anticyclogenesis and a major anticyclone track are often observed. This region in western Canada is an exporter of highs to the United States and is a reservoir of cold air. Each new outbreak is usually accompanied by increased jet stream activity.

Between 125°E and 145°E the incidence of jet streams reaches a minimum. Note the fact that the greatest frequency of cyclone tracks is located near the 50th parallel in this area (see table 1.1d). Actually, the greatest incidence of jet streams in this area will be found at about 40°N. The secondary cyclone track between 75°N and 80°N is not reflected in jet stream incidence to any marked degree though some rearrangement of the incidence is apparent. This is due to the fact that any such jet streams would be Arctic jet streams which may not reach the necessary velocity criteria at 500 mb [6] or sparse data may preclude an adequate analysis.

Since most of the major features of the seasonal distribution of jet stream incidence are also found in the monthly data (fig. 1.12), though varying in degree, they will not be discussed individually.

1.2.3 Summer

The results of summing the total number of occurrences of jet stream centrums over thirty-five degrees of latitude (50°N - 85°N) by 10 degree sectors of longitude are shown in figure 1.13.

In the summer there exist three longitudinal regions of maximum incidence of jet stream centrums. The primary one is centered along 20°W while secondary maxima are centered along 155°W and 90°W respectively.

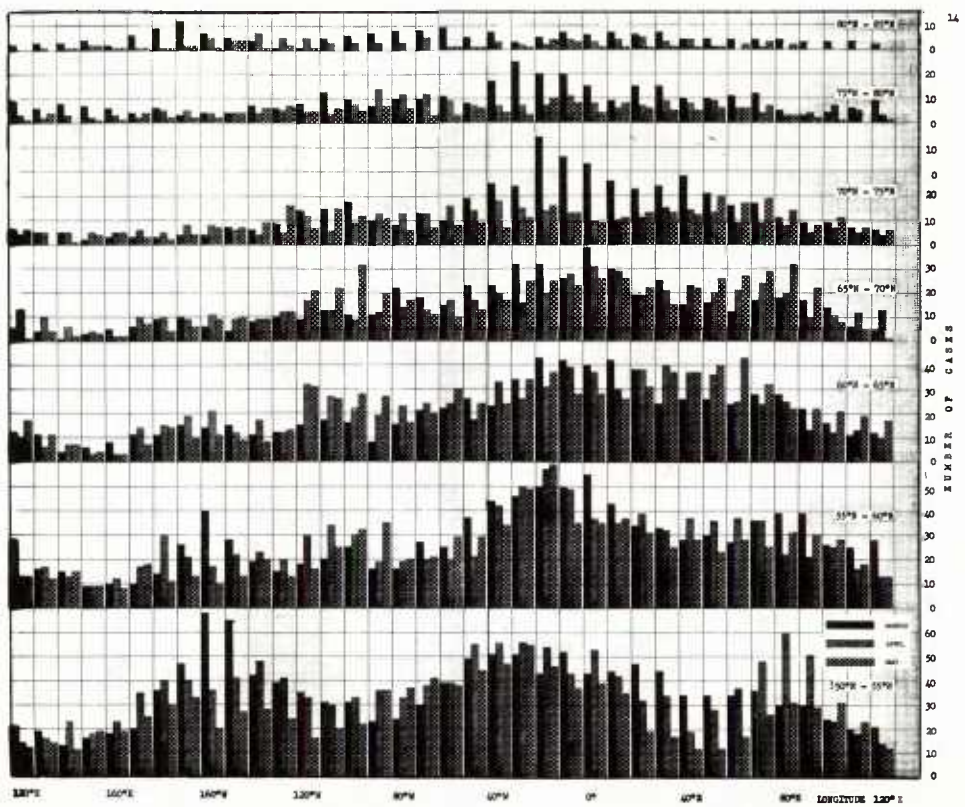

Figure 1.12. Total Incidence by Latitude Band and Month of Jet Stream Centrums for Spring for Five Year Period.

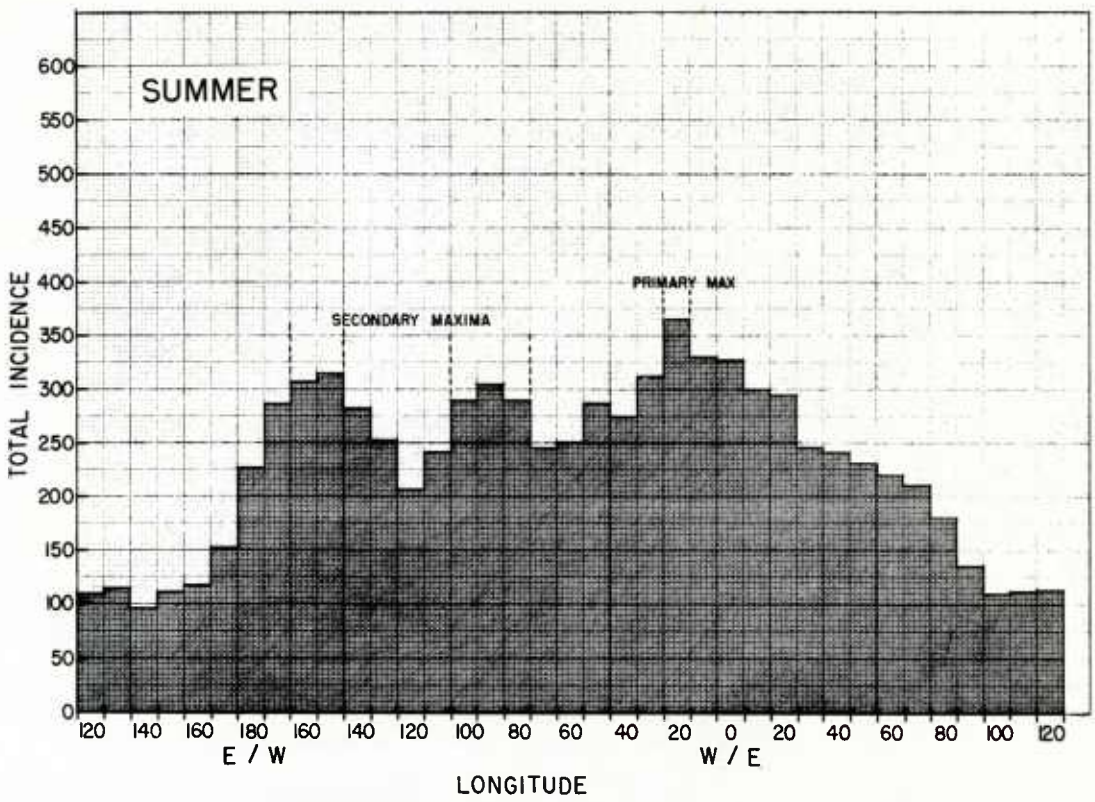

Figure 1.13. Total Incidence of Jet Stream Centrums in 10 Degree Sectors of Longitude Summed over Latitudes 50°N. - 85°N. for Summer.

The predominant wind direction associated with the primary maximum is from the southwest (fig. 1.14). The primary maximum is found downstream from a mean trough at approximately 70°W (see fig. 1.15). This quasi-permanent trough is found in about the same position during the summer as in winter (fig. 1.3). Probably the actual maximum jet

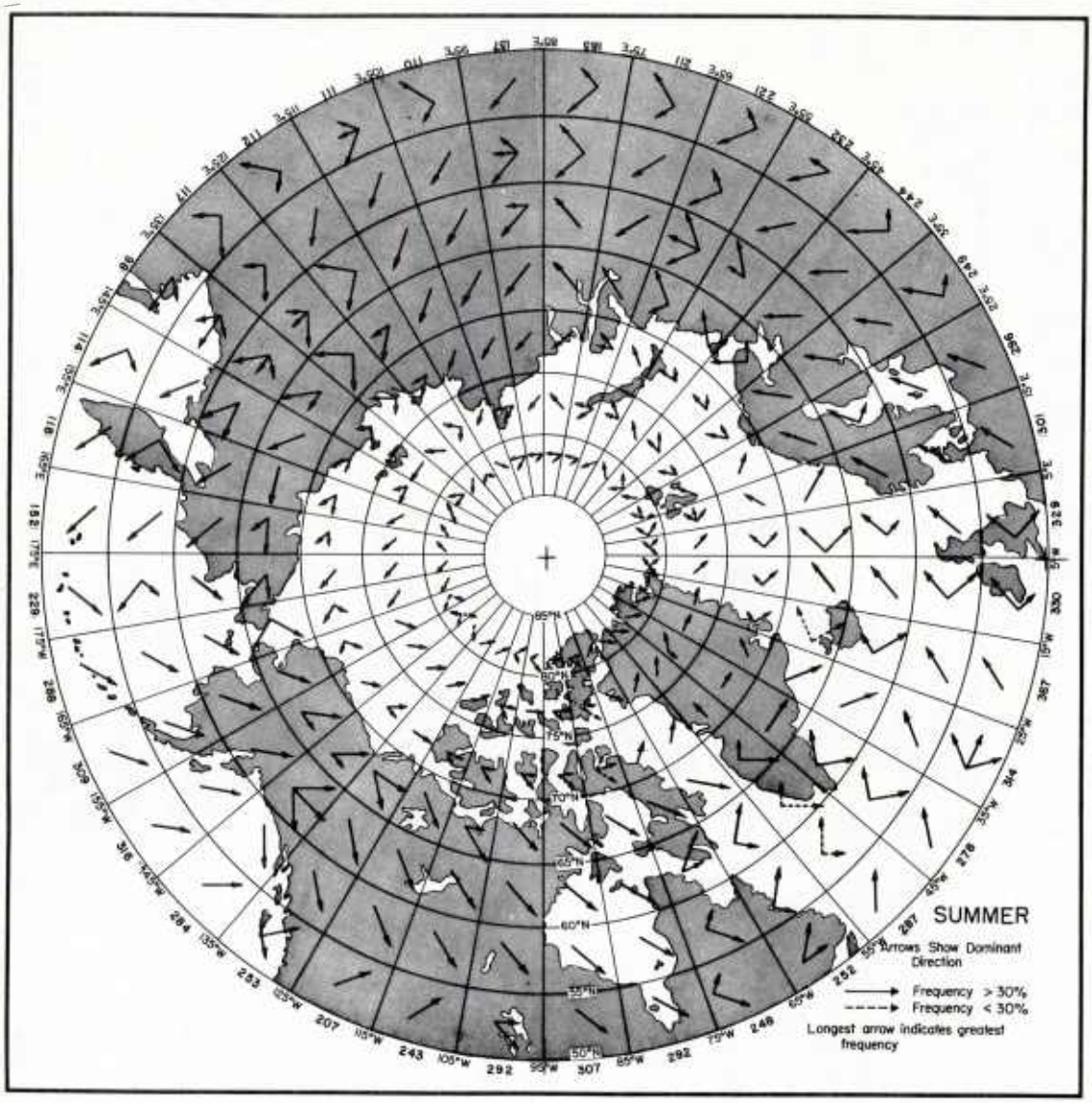

Figure 1.14. Dominant Orientation of Jet Stream Centrums for Summer.

stream incidence in this area is south of 50°N along the base of the trough with a dominant direction from the west.

Similarly, the secondary maximum centered about 155°W is seen to be downstream from a major trough on the mean 500 mb chart for

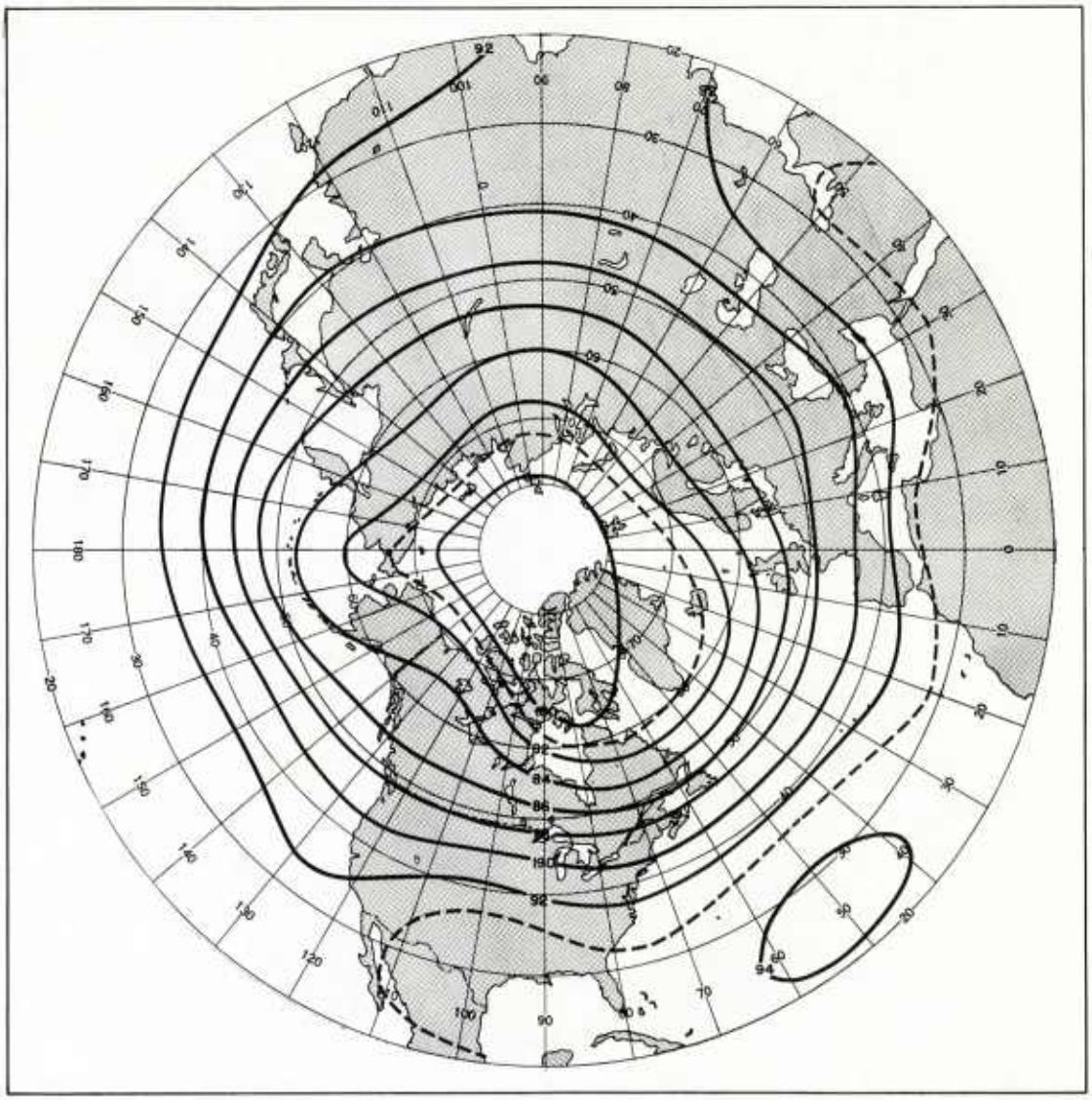

Figure 1.15. Summer Mean 500 Mb. Chart. Heights Are Given in Hundreds of Feet.

summer (fig. 1.15). However, the secondary maximum centered about 90°W is slightly upstream from a major trough on the mean 500 mb chart and hence the predominant direction of jet stream winds is northwest, as would be expected.

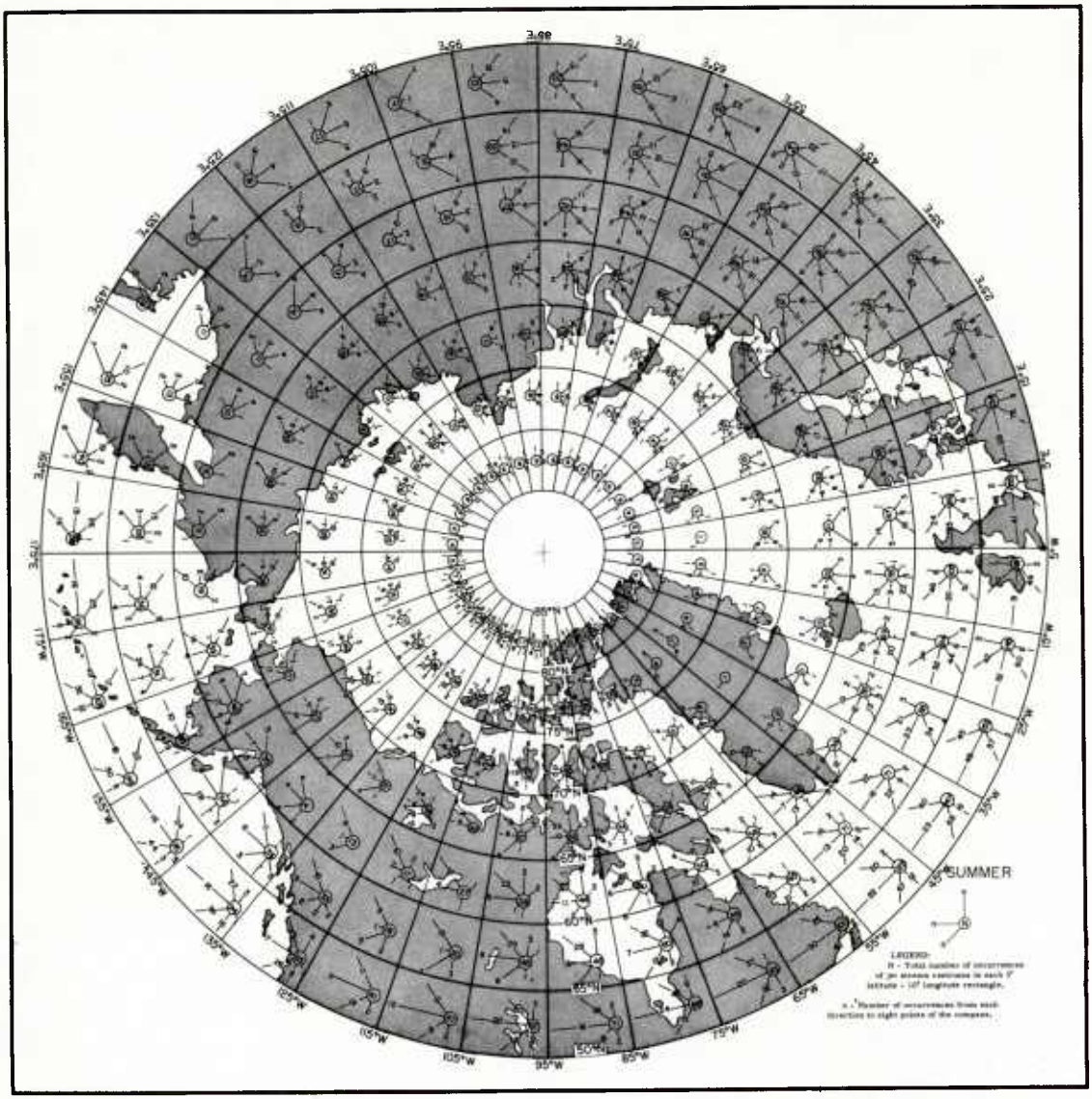

Figure 1.16. Frequency and Direction of Jet Stream Centrums for Summer.

If individual sectors or latitude bands are considered, it is seen from figures 1.16, 1.17 and 1.18 that in latitudes between 50°N - 60°N the maximum incidences are located at about 30°W and 170°W, while in latitudes above 60°N, the maximum incidences are located at about 40°E and 140°W. There appears to be a shifting to the east, with in-

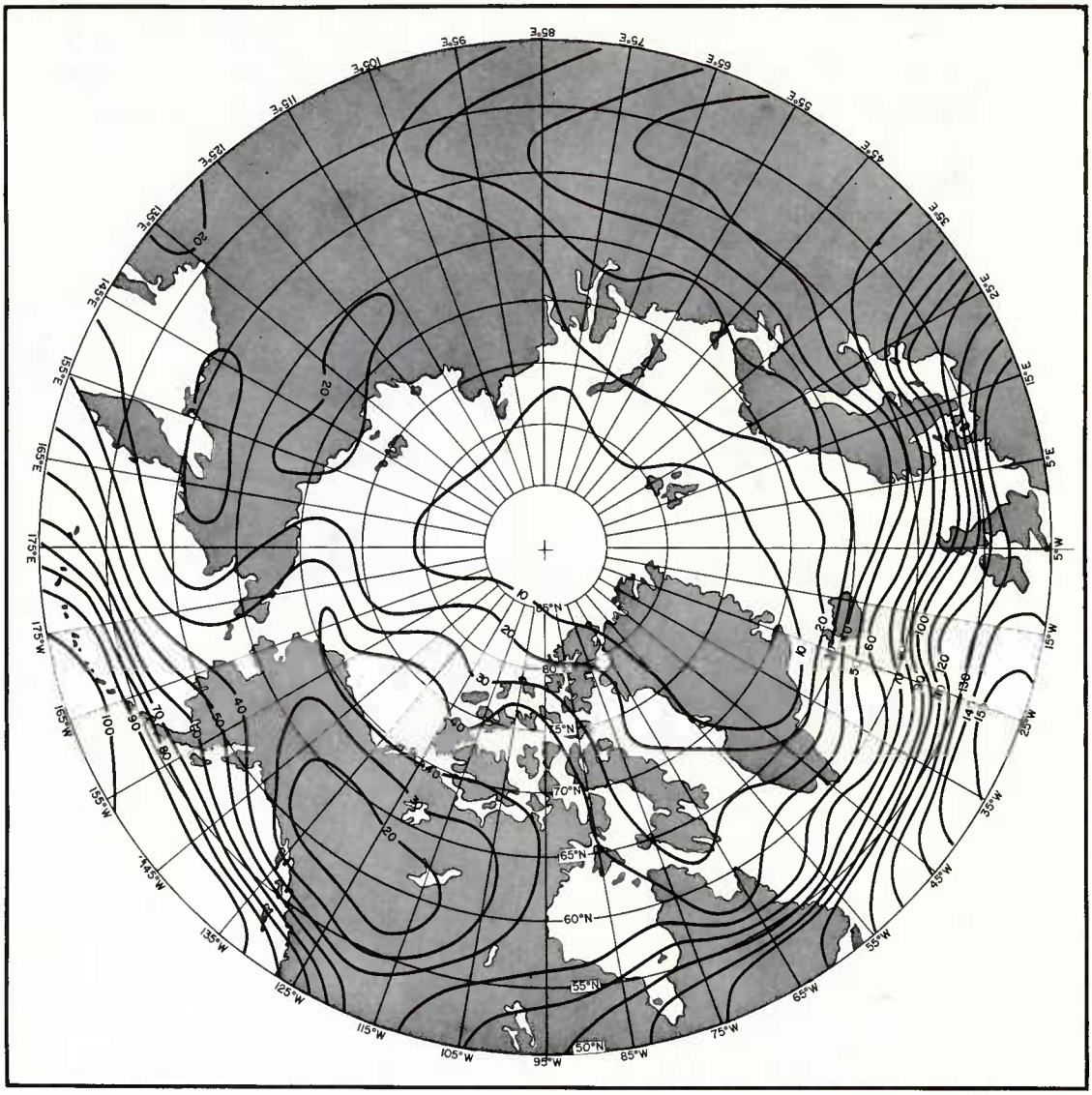

Figure 1.17. Isopleths of Total Incidence of Jet Stream Centrums for Summer. (From data in fig. 1.16.)

creasing latitude, of the areas of maximum incidence of jet stream centrums. It should also be noted that the weak contour gradient exhibited by the summer mean 500 mb chart (fig. 1.15) is reflected in the rather small count of jet stream centrums during summer.

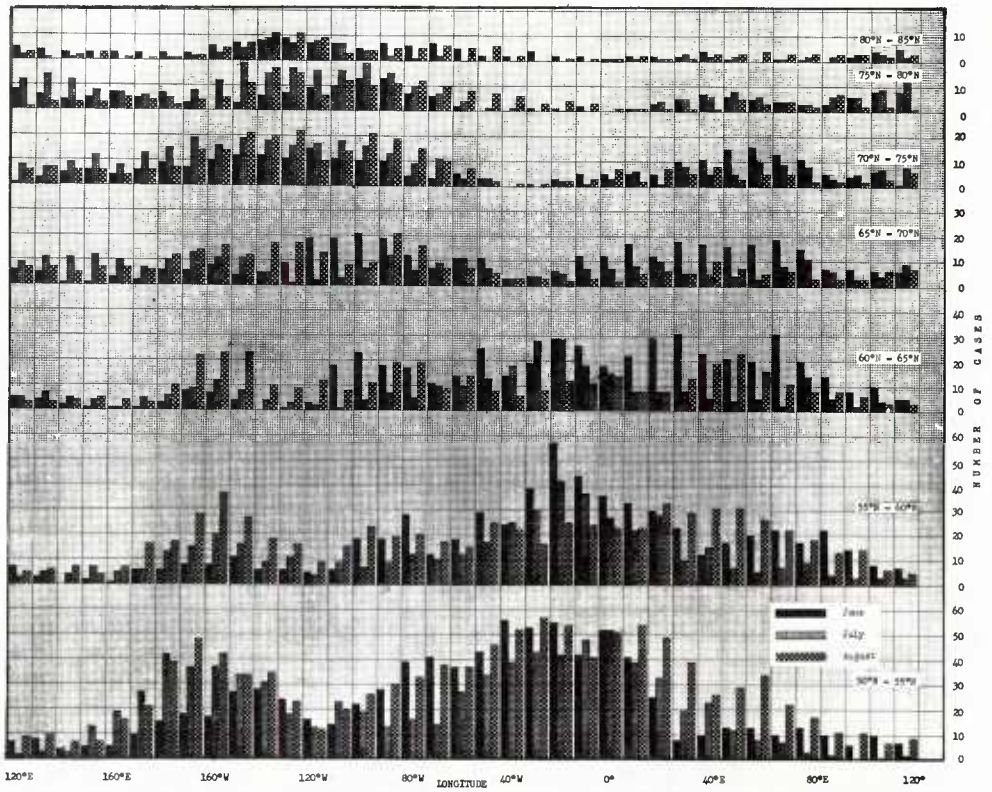

Figure 1.18. Total Incidence by Latitude Band and Month of Jet Stream Centrums for Summer for Five Year Period.

1.2.4 Autumn

From figure 1.19 it is apparent that during autumn, as in other seasons, there are preferred longitudes of maximum total incidence of jet stream centrums. The primary longitudinal maximum is centered about 20°W with secondary maxima at 145°W and 110°W.

In the area of the primary maximum (25°W to 15°W) the dominant orientations are primarily westerly (fig. 1.20).

From 35°E to 115°E the jet stream orientations are largely bidirectional, resulting from the variety of pressure patterns and amplitudes that may actually prevail, the lack of data in this region, and the resulting inconsistencies in analysis. The presence of the Asiatic

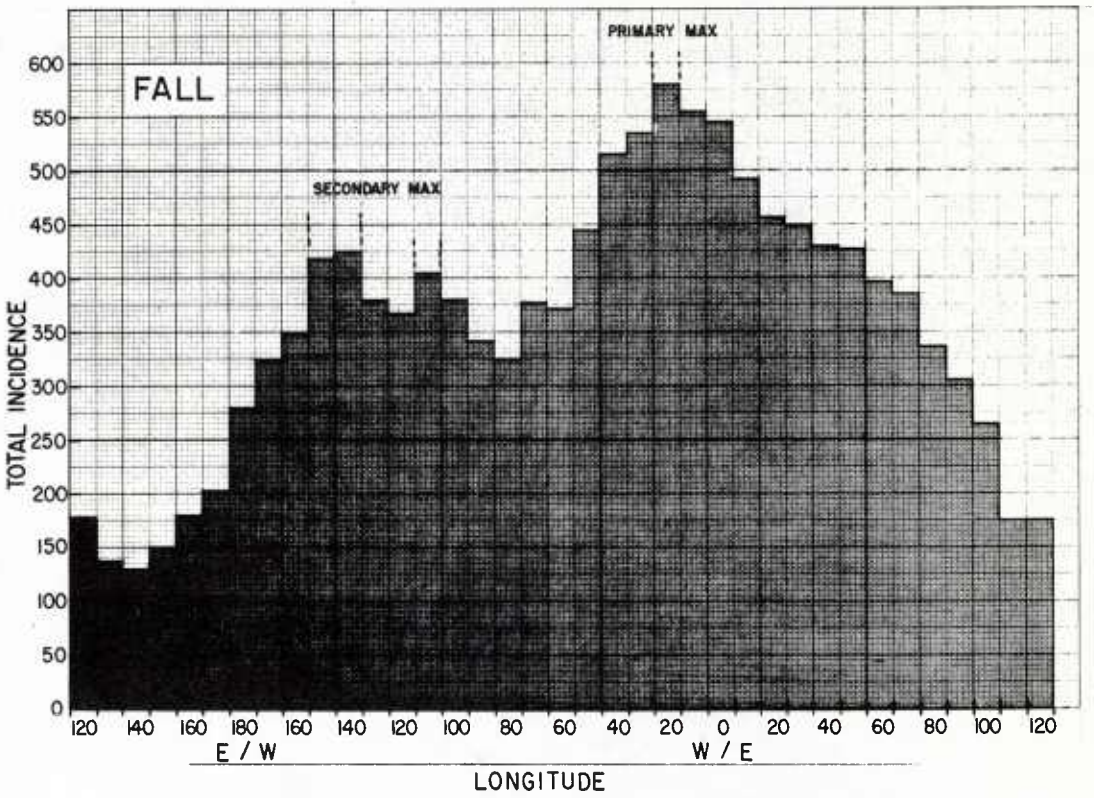

Figure 1.19. Total Incidence of Jet Stream Centrums in 10 Degree Sectors of Longitude Summed over Latitudes 50°N. - 85°N. for Fall.

mean trough (fig. 1.21) becomes apparent from Siberia to about 160°W. In this area the dominant directions are either southwesterly or northeasterly, attesting to the various locations of this trough on a daily basis.

Further downstream the dominant directions indicate a mean

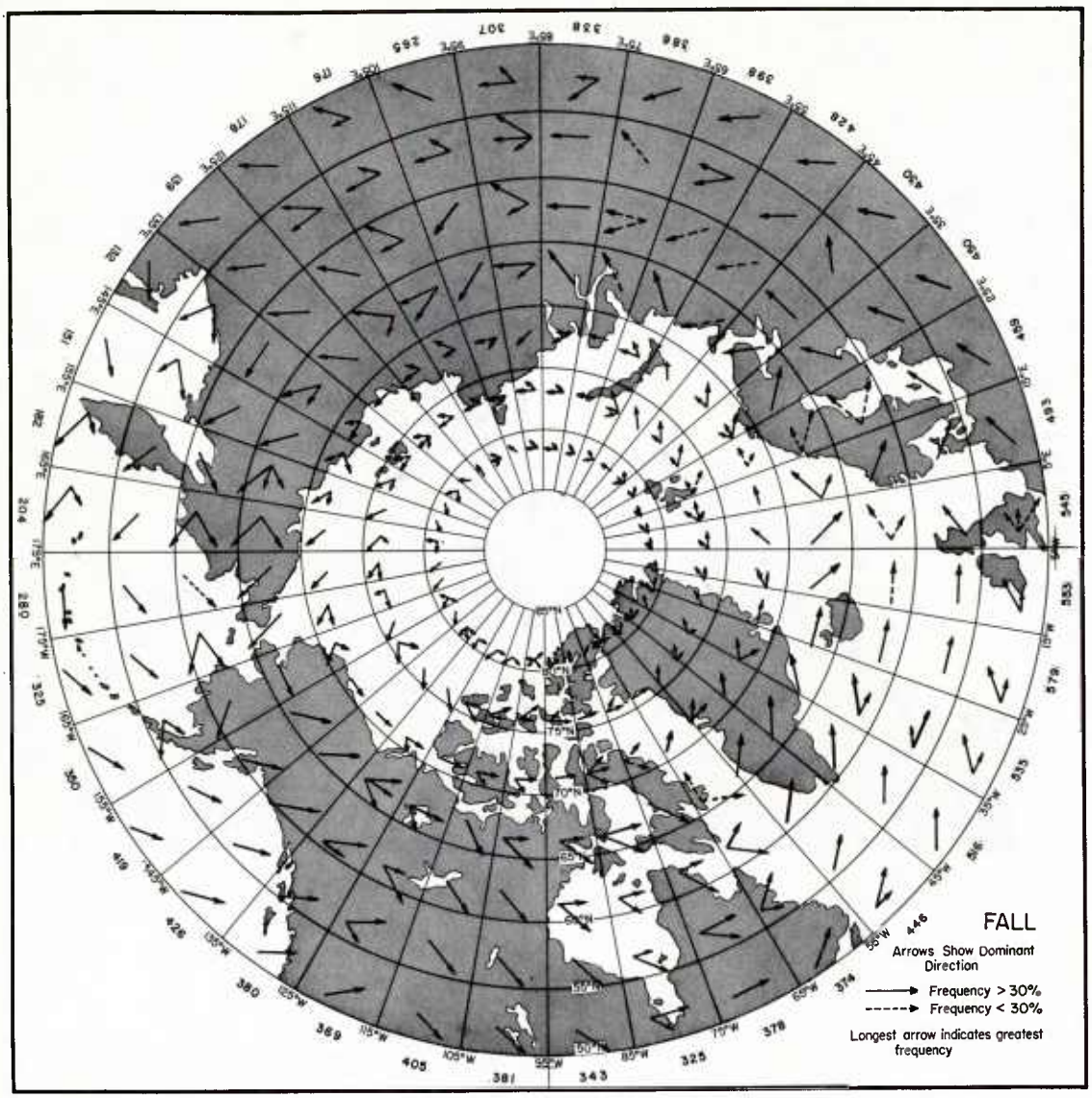

Figure 1.20. Dominant Orientation of Jet Stream Centrums for Fall.

ridge centered at 125°W to 115°W. This ridge is duplicated on the mean chart (fig. 1.21), though exhibiting a lesser amplitude.

From 115°W to 35°W the dominant directions clearly indicate the prevalence of a trough between eastern Canada and the Davis Straits, a location which closely approximates that of the mean trough in this area.

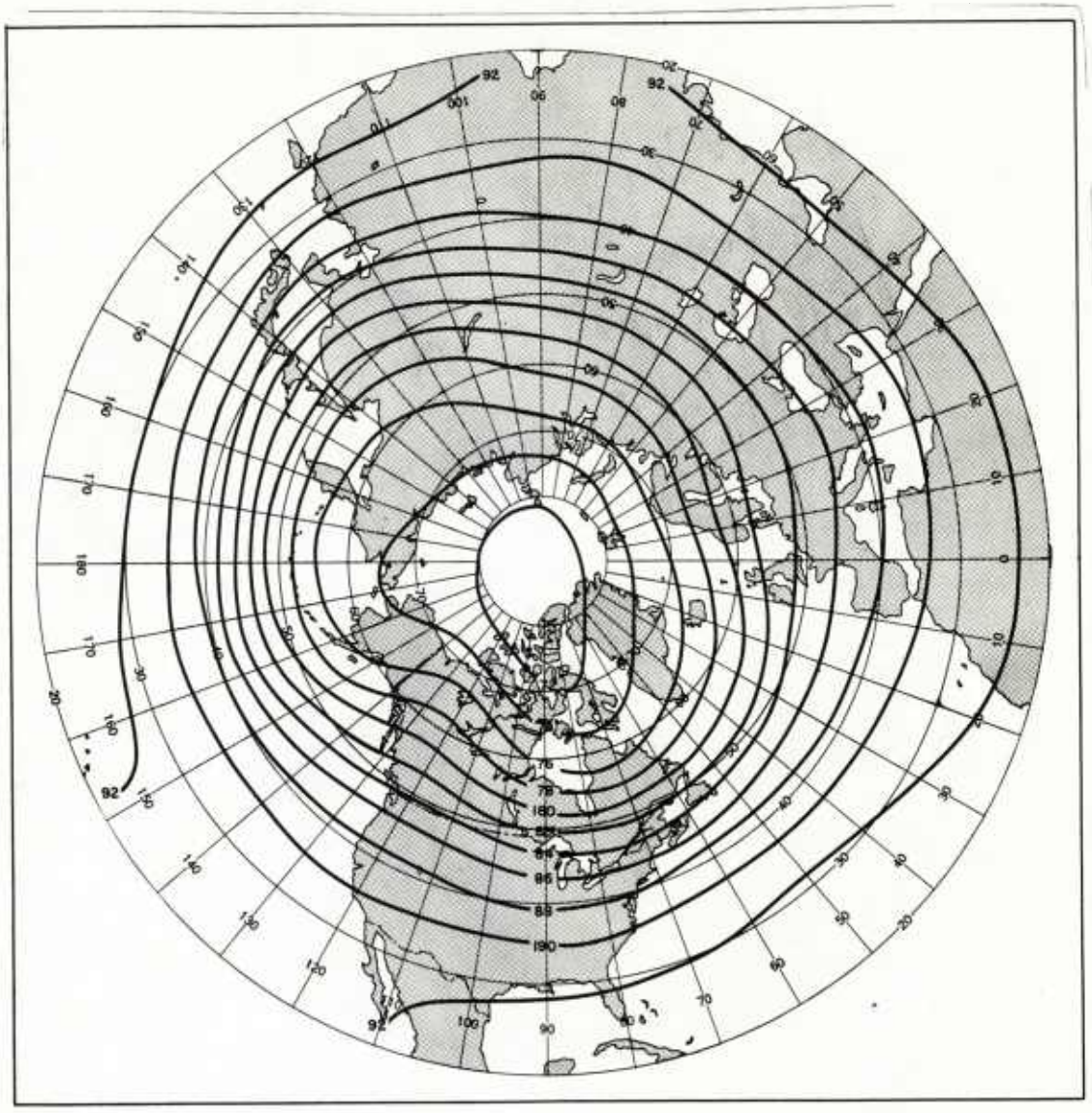

Figure 1.21. Fall Mean 500 Mb. Chart. Heights Are Given in Hundreds of Feet.

In general, then, the distribution of the dominant jet stream directions parallels the location and configuration of the major trough and ridges as expressed on the 500 mb mean chart.

Of major interest is the close association between the distribution of incidence north of the 50th parallel by individual sectors and major

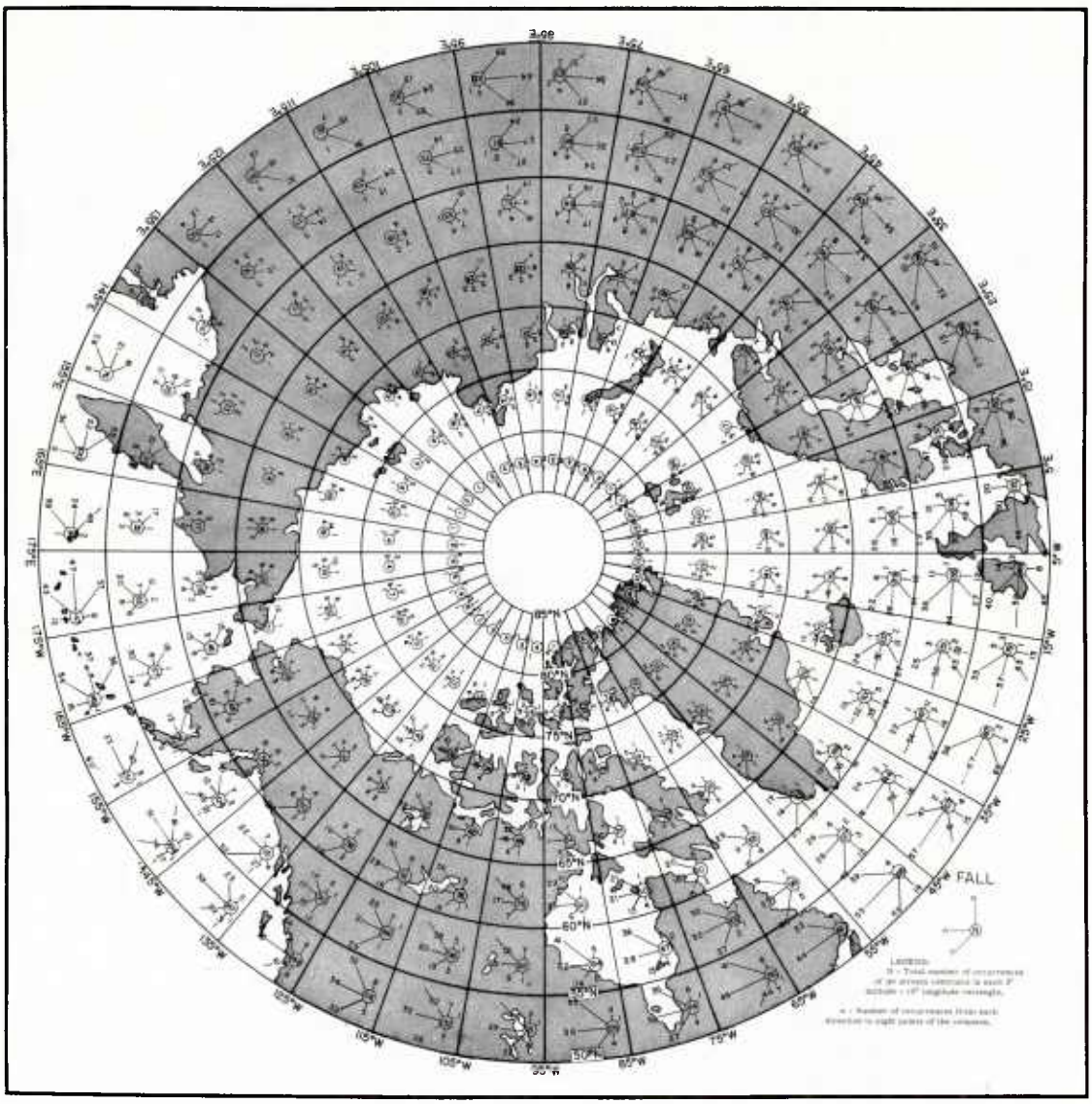

Figure 1.22. Frequency and Direction of Jet Stream Centrums for Fall.

cyclone and anticyclone tracks [1] as shown in figures 1.22 and 1.23.

Essentially, the isopleths of hemispheric jet stream incidence north of 50°N during Autumn tend to be circular, decreasing in magnitude northward. The entire distribution is somewhat asymmetrical with respect to the north pole. The maximum incidence lies within the

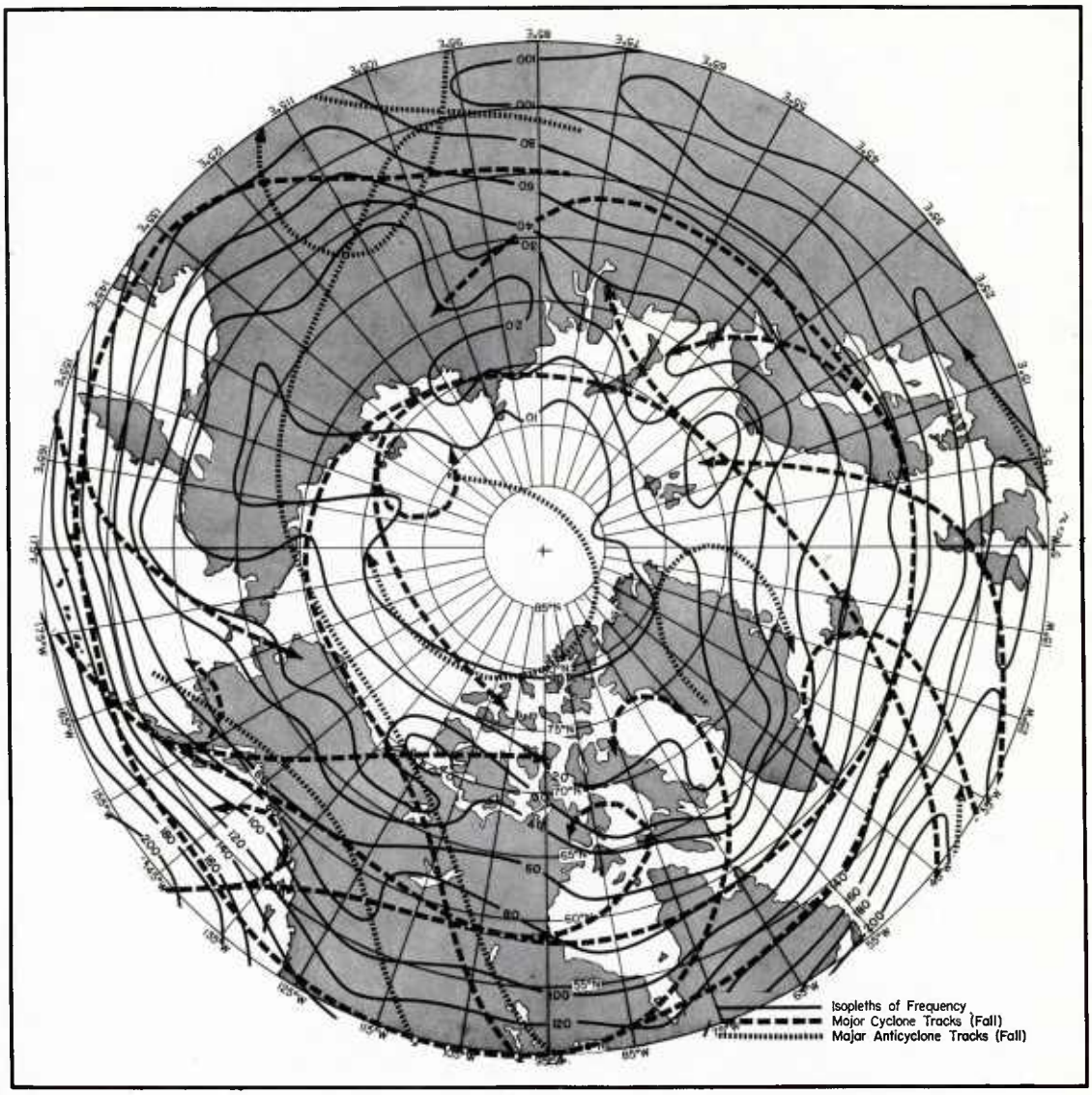

Figure 1.23. Isopleths of Total Incidence of Jet Stream Centrums for Fall. (From data in fig. 1.22.)

50°N - 55°N latitude band from 55°W to 105°E. Certain local deviations in this pattern, due to various synoptic reasons, are apparent, however.

Between 25°W and 15°W the great incidence of frequency from 50°N to 55°N appears to be associated with the west-east cyclone path near the 60th parallel. In table 1.1, column (a), the greatest cyclone

crossing frequency at 15°W is reported between 55°N and 65°N latitude.

Downstream at 25°E longitude two major tracks are evident - one at 60°N latitude and a second near 75°N. The maximum jet stream incidence near 55°N is perhaps associated with cyclone paths between 60° and 65°N. The relationship between the distribution of jet stream incidence and the cyclone path at 75°N is not readily apparent. Table 1.1, column (b), indicates that at 25°E longitude a maximum cyclone crossing frequency is reported between 70°N and 80°N; however, there appears to be little indication of a band of maximum incidence to associate with it. Perhaps at this time of year these high latitude cyclones are not sufficiently intense to cause 50 knot winds at the 500 mb level, though the lower latitude cyclones are, or perhaps the inconsistency and unreliability of synoptic analyses at these high latitudes prevent detection of any such relationships on a statistical basis.

This same double cyclone track pattern mentioned above persists to 95°E. In this area the greatest incidence of jet streams is still confined to the latitude span 50°N - 55°N, indicating a more striking association with the cyclone track at 60°N than with the one at 75°N. Sparse data coverage in Russia may play a part in this discrepancy, but it is felt that the delineation is more real than spurious. In table 1.1, column (c), the greatest frequency of cyclone crossing occurs in the span 65°N - 80°N.

Between 95°E and 145°E multiple cyclone paths continue to be evident. The southerly track penetrates southward nearly to the 50th parallel at 140°E while the northerly track remains between 70°N and 75°N. Correspondingly, the incidence of jet stream occurrence falls off appreciably north of the 50th parallel. This major southerly shift in track is apparent in table 1.1, through a comparison of columns (c) and (d) the latter of which indicates cyclone-crossing maxima between 75°N - 80°N and 50°N - 55°N, respectively.

Between 145°E and 175°W the isopleth field undergoes a northward displacement, reflecting the reappearance of major jet stream activity north of the 50th parallel. Cyclone paths continue to be located near the 55th and 70th parallels. Note the extreme gradient of incidence across the Pacific near the 50th parallel. Little jet stream activity is reported in association with the northerly track. Table 1.1, column (e), shows a high incidence of cyclone crossing frequencies at

175°W between 50°N - 55°N and again at 70°N - 75°N.

The area from 175°W to 95°W embraces the location of a ridge at 115°W on the mean chart. Though there is a great divergence of cyclone tracks east of 165°W the general northward penetration of cyclone and anticyclone tracks in the area of the mean ridge is accompanied by a corresponding northward increase of jet stream incidence. On figure 1.23, most of the tracks lie between 50°N and 65°N. This "fact" might be implied from the charts shown, but some other jet-stream-climatology must be referenced to demonstrate this more conclusively. The gradient of incidence remains strong between 175°W and 125°W but relaxes considerably beyond that longitude. Between 125°W and 95°W frequencies of jet stream occurrence stem from a multitude of cyclone tracks of which the one extending from the Canadian Arctic into the eastern United States seems the most important. Indeed, the dominant jet stream directions in this area indicate a definite preference for northwesterly flow, (see fig. 1.20). Table 1.1, column (f), indicates an appreciable cyclone-crossing frequency at 95°W between 50°N - 65°N with a secondary maximum between 70°N and 75°N.

From 95°W to 15°W the isopleths of incidence reflect the persistent location of jet stream activity around the base of a mean trough centered near 75°W (fig. 1.21). Figure 1.23 shows that cyclones have a tendency to spiral into this "Mean Low" and stagnate which contributes to a greater incidence of jet streams at high latitudes in this area compared to a similar location in the region of the Western Pacific mean trough. In table 1.1, column (g), the highest incidence of cyclone-crossing frequency at 55°W lies between 50°N and 65°N.

In summation, the distribution of jet stream activity north of the 50th parallel during the fall season is characterized by a nearly hemispheric maximum of incidence along the 50°N - 55°N latitude band. Also the region of maximum planetary westerlies on the mean chart coincides with the region of maximum jet stream incidence.

Figure 1.24 shows the contribution of the individual months of September, October and November to the seasonal incidence. In general the primary maxima during all months is found along the longitudes between 50°W and 20°W. In September and October the peaking of incidence in the various latitude bands is not well marked above the 55th parallel. By November, however, considerable redistribution

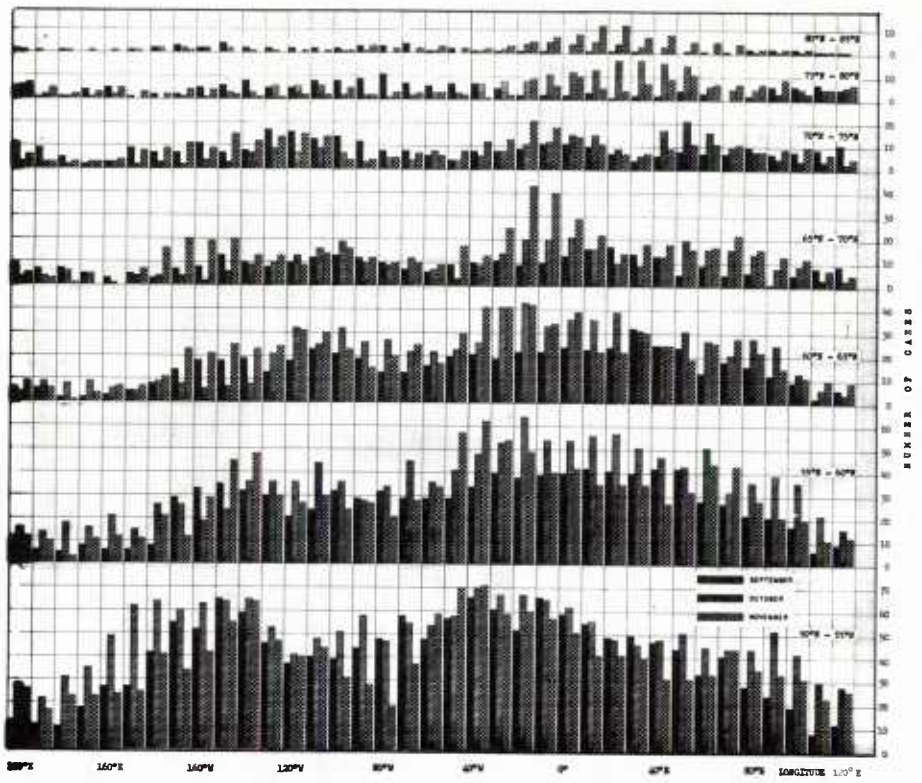

Figure 1.24. Total Incidence by Latitude Band and Month of Jet Stream Centrums for Fall for Five Year Period.

occurs, culminating in a sharp peak of incidence as far north as 75°N. This pronounced increase in November reflects the increase in cyclone occurrences as winter approaches and, to some extent, the reappearance of strong winds at the 500 mb level not present earlier.

Another maximum is found near 140°W particularly between 50°N - 55°N. Here again, as the fall season progresses, the distribution of incidence becomes more marked at increasingly higher latitudes. Compare September with November. By November a sharp peak in incidence extends to about 75°N and carries through the winter.

A fairly well-defined secondary maximum between 55°N and 70°N is located at about 70°E in November and continues through the winter at this location. Note the general decrease and/or regrouping in incidence from October to November. This development is related to the

reestablishment and expansion of the circumpolar westerlies as winter approaches.

In general the monthly change in incidence is not uniform in all areas and between all months.

1.3 Seasonal Comparisons

The ten years of data used in this investigation indicate (fig. 1.25) that the total number of jet stream centrums occurring at 500 mb between the latitudes of 50°N - 85°N reaches a maximum in Fall although the total observed for Spring is very nearly as large. On the same basis, the Summer total is the smallest while the Winter total lies between those for Spring and Summer. While the season-to-season changes appear quite large, figure 1.25 indicates nothing about spatial

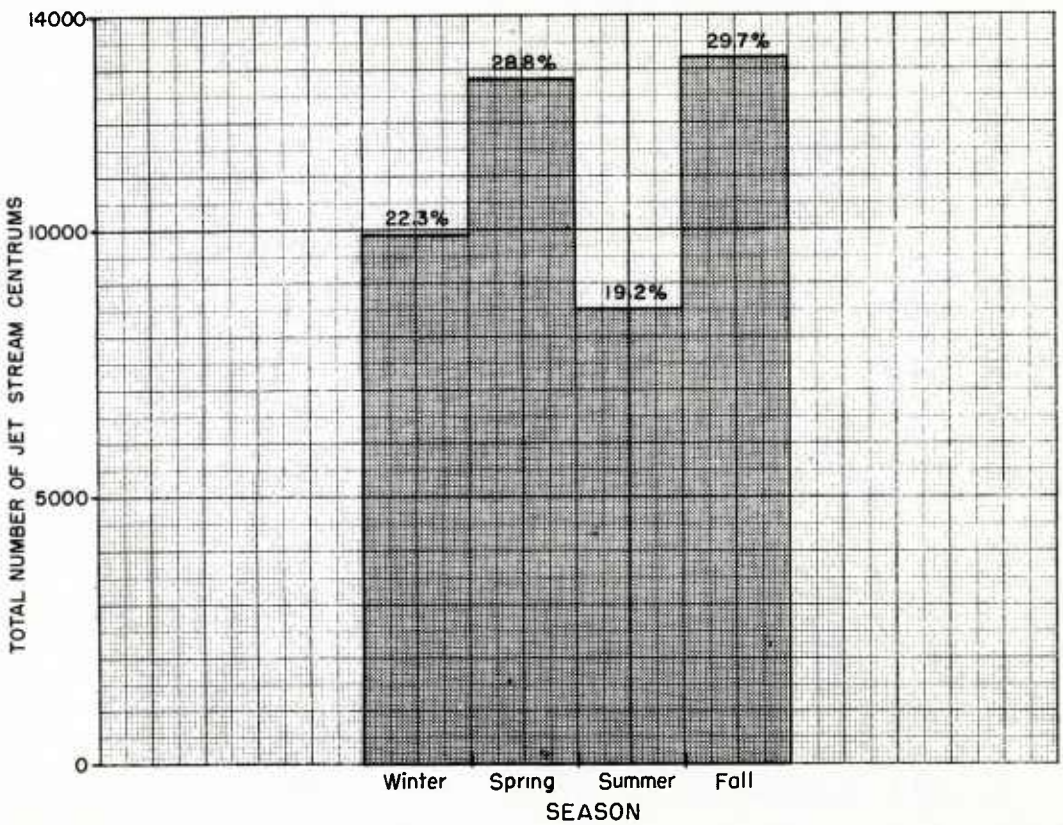

Figure 1.25. Total Count of Jet Stream Centrums Between 50°N. and 85°N. for Each Season for Five Year Period.

distribution of jet stream centrums.

Figure 1.26 affords some insight as to the longitudinal distribution of jet stream centrums on a seasonal basis. It shows the total number of jet stream centrums (ordinate) observed in each 10° of longitude (abscissa) when summed over the latitude band 50°N - 85°N.

All four seasons exhibit absolute maxima in the vicinity of 20°W (Alaska) and relative maxima near 150°W (Iceland). Similarly, all four seasons exhibit absolute minima in the vicinity of 120°W (northwestern Canada) and relative minima near 140°E (eastern Siberia).

The most pronounced seasonal change occurs between Spring and Summer at 20°W where the total count decreases from 611 in Spring to 370 in Summer. In contrast at 170°W, the totals for Spring and Summer are virtually identical.

This figure only reflects seasonal and longitudinal variations in distribution of jet stream centrums and says nothing concerning the latitudinal variations.

In order to gain a more complete picture of the distribution of jet stream centrums with latitude, longitude and season, figures 1.27 and 1.28 are presented. Figure 1.27 summarizes the data in figures 1.4, 1.8, 1.12, and 1.16. The length of each line segment is proportional to the total number of jet stream centrums observed in that particular sector during a particular season. Figure 1.28 was derived by noting the season during which a maximum total of jet stream centrums was observed in each sector.

In general, on the basis of these figures, it can be said that between 50°N and 55°N, the maximum jet stream occurrence is in the Fall. There is a large region extending eastward from 75°W to 105°E throughout which there is a Fall maximum between 50°N and 60°N and a Spring maximum between 60°N and 80°N. In only a very few instances do individual sectors in this large region show maxima in seasons other than Spring or Fall. However, the pattern of distribution of jet stream centrums in the rest of the Northern Hemisphere north of 50°N is more complicated in that areas of maximum occurrence are present for all four seasons. The only area of Winter maxima is located in the Eastern Siberia - Alaska region while two areas of Summer

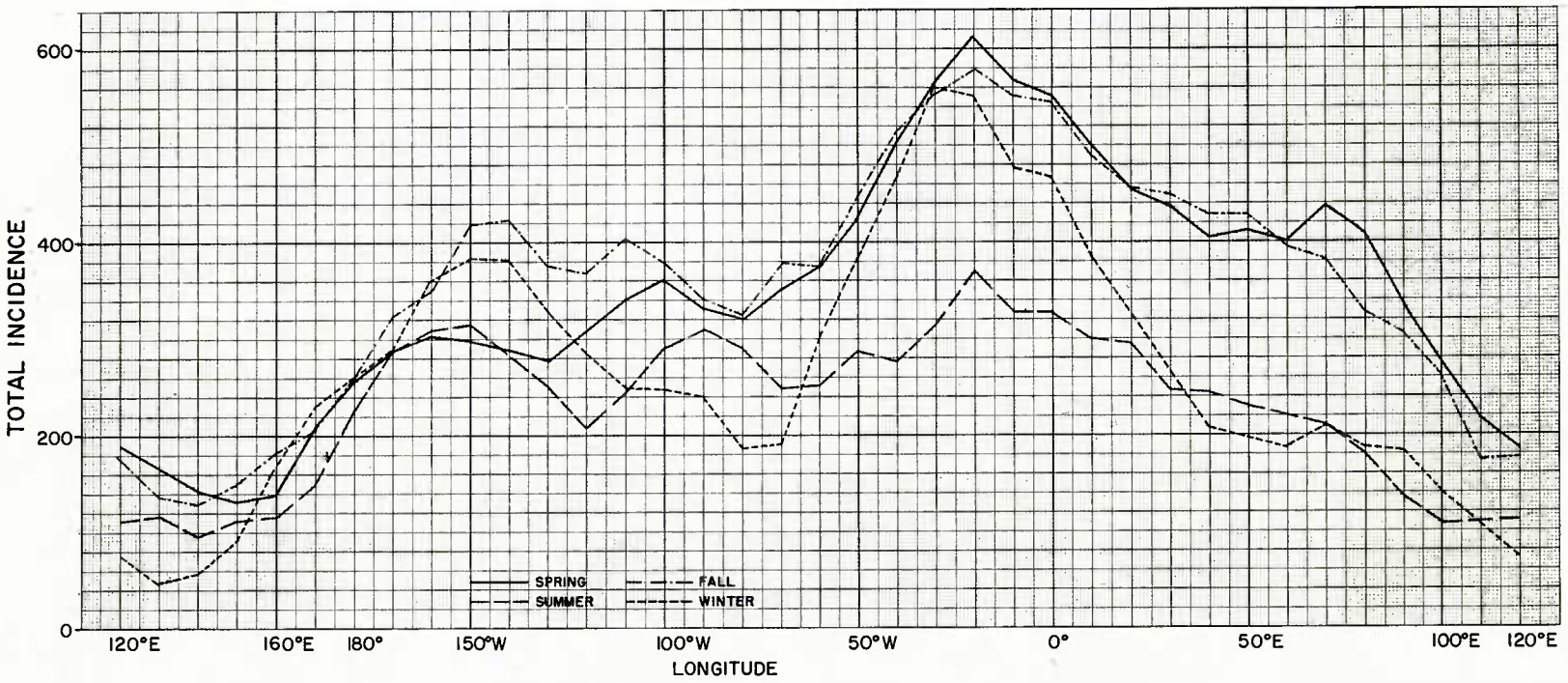

Figure 1.26. Total Incidence of Jet Stream Centrums by Sectors Measuring 10° of Longitude and Extending from 50°N. to 85°N. over a Five Year Period.

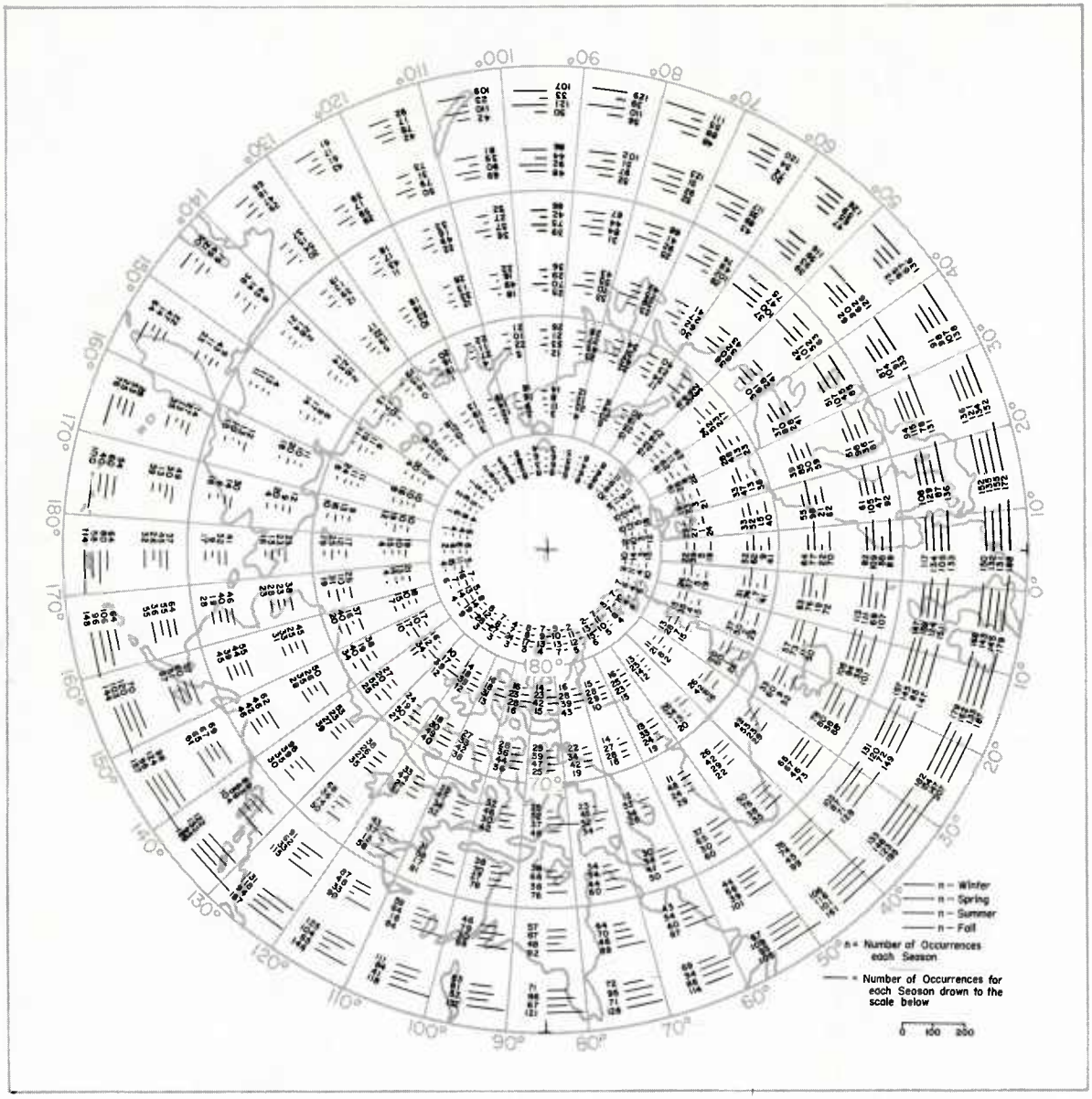

Figure 1.27. Five Year Seasonal Totals of Jet Stream Centrums North of the 50th Parallel by Individual Sectors.

maxima are indicated; one bounded by the latitudes of 70°N - 85°N and 60°N - 80°N and by the longitudes of 75°W - 155°W and 115°E - 165°E respectively.

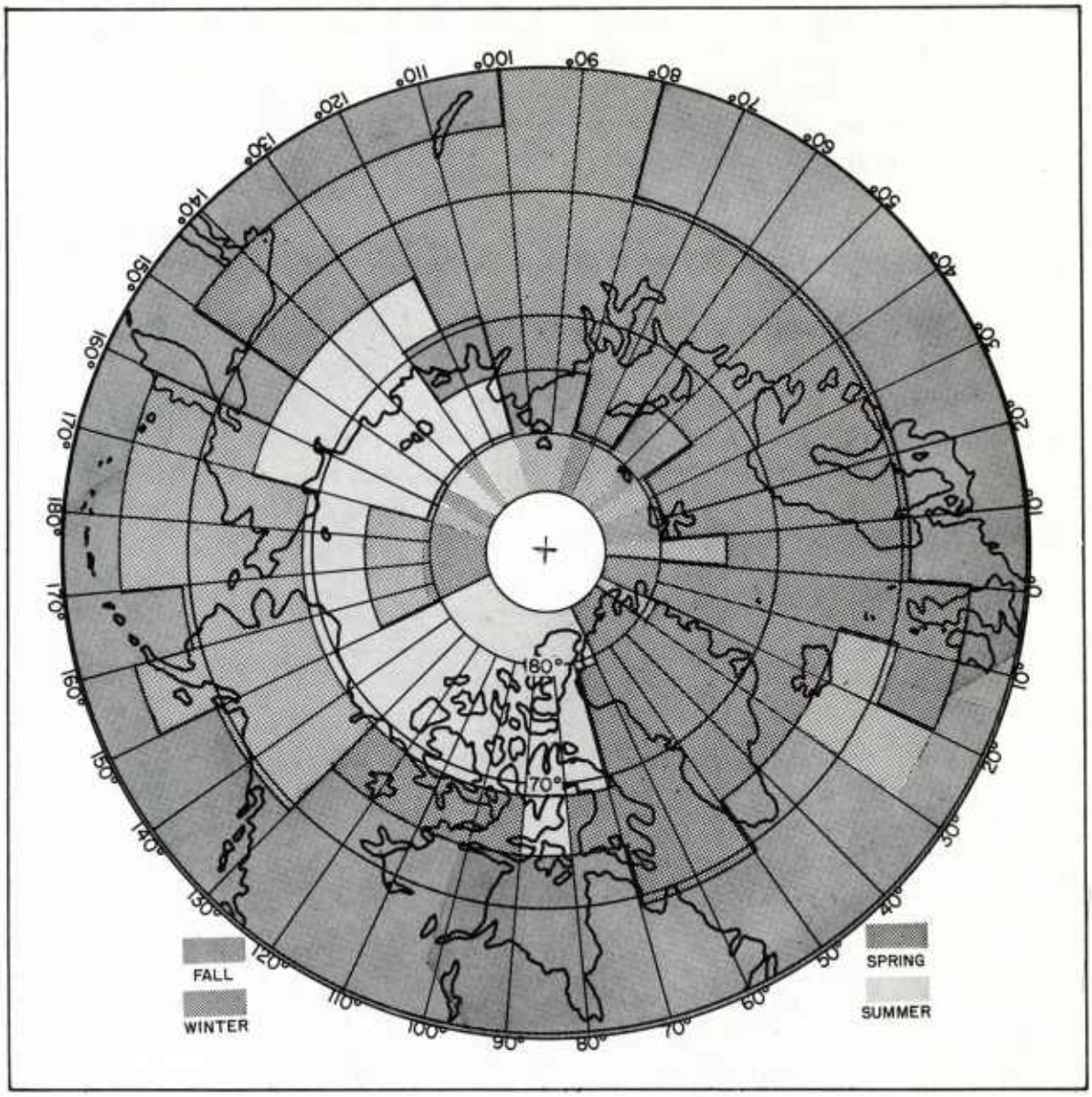

Figure 1.28. Areal Chart Showing Season during which Maximum Number of Jet Stream Centrums Occurs at 500 Mb.

1.4 Summary and Conclusions

On the basis of 5 years of one-per-day 500 mb charts, jet stream centrums (as defined in the Preface) were tabulated for that portion of the Northern Hemisphere between 50°N and 85°N. The following re-

marks will summarize the main results of the investigation.

(1) The dominant orientation of jet stream centrums on a seasonal basis, in general, parallel the mean 500 mb contours for that season.

(2) Relatively small monthly changes contribute to quite large seasonal changes in the total number of jet stream centrums observed. This is true for individual sectors, for longitudinal strips 10 degrees wide and 35 degrees long, as well as for the entire area studied.

(3) Spring and Fall are the favored seasons for occurrence of jet streams at 500 mb whereas Summer is the least favored except in the region of the Canadian Archepelago and northeastern Siberia.

(4) With some exceptions, the total number of jet stream centrums occurring in a given area appears to decrease with increasing latitude.

(5) The longitudinal sector bounded by 15°W, 25°W, 50°N and 85°N is a favored region for jet stream occurrence the entire year. The total number of jet stream centrums observed in this region for Spring was the absolute maximum encountered in this study.

In general, the temporal change in incidence is not uniform in all areas and between all months and seasons. Although it is recognized that some of the quantitative differences are undoubtedly due to the lack of data and the subjectivity of the analyses, the monthly and seasonal changes, considered qualitatively, must be regarded as real. For significant correlations with respect to area and seasonal changes in storm tracks, cyclogenetic and anti-cyclogenetic areas, a study would necessitate an extensive backlog of high level maps with more complete networks of data in order that the true core position could be determined and not just its appearance at one level in terms of a specified velocity criteria.

Although the data presented in this chapter contain a certain amount of subjectivity, as noted earlier, they nevertheless should prove to be of value to the operational forecaster in several ways. As guides

to long range planning of flight operations, the charts presented here can serve as useful aids in taking advantage of the jet stream at 500 mb, particularly where the intended operations are not restricted to a particular season. To a more limited degree, the data presented in part one supplement and confirm much of the knowledge concerning mean jet stream conditions at 500 mb that many forecasters have gained through experience.

Since the operational forecaster is perhaps more concerned with daily contour patterns and the location of cyclones and anticyclones than he is with monthly and seasonal totals of jet stream centrums in specific areas, chapter 2 of this report will be concerned with showing the location of jet streams at 500 mb when various "blocking" situations are present in specific geographic areas.

2. A CLIMATOLOGICAL CATALOGUE OF THE LARGE SCALE JET STREAM PATTERNS THAT ARE APPARENT WHEN BLOCKING CONDITIONS EXIST IN SPECIFIC GEOGRAPHIC REGIONS.

2.1 Introduction

The preceding sections highlighted some of the significant associations between the distribution of jet stream occurrence and certain features of the mean 500 mb flow patterns. The purpose of this chapter is to extend the discussion to include certain large scale jet stream patterns that are apparent when blocking conditions exist in specific geographic regions. Although blocking systems are by no means the majority of pressure patterns, there does appear to be a close association between frequency of blocking action in specific areas as reported by several authors [2, 7, 8] and the frequency of occurrence of jet stream centrums in the same areas as noted in chapter 1 of this report.

Blocking situations were selected from a ten year series of maps using the criteria presented by Elliott [4] - to wit; a long wave ridge that exhibits a closed contour at the 500 mb level and exists for at least three consecutive days. The necessity for a closed contour at the 500 mb level, in itself does not contribute to the jet stream configuration but merely insures, to some extent, that a well developed long wave ridge has been selected. Although some long wave ridges caused jet stream configurations similar to those observed during blocking regimes they were not included in this study.

Those blocking situations that resulted in specific and characteristic jet stream patterns were catalogued. Although the census in chapter 1 was for every other year during the ten year period the delineation of the block types included every year of this ten year period. A scattergram of block locations was made and geographic regions of significant incidence were selected from this aggregate.

The blocks that were selected existed in a given rectangle of latitude and longitude for three or more days. Other blocks existed as such but were not confined to the same rectangular area for three days. Consequently, it must be emphasized that not all possible block locations were delineated; only those that occurred most frequently and experienced the least drift were selected. Figures 2.1, 2.15, 2.24 and

2.35 illustrate the geographical distribution of the selected blocking regions.

The next objective was to consider the distribution and configuration of those jet streams that were apparent in the Northern Hemisphere on the 500 mb chart when these "key" blocks existed in a given region. This was done in the following manner; the jet stream centrums were delineated on the 500 mb charts for each of the date sequences comprising the catalogue of the block type and then combined on a single chart. From this composite the area within which 90% of the jet stream centrums were observed was constructed. In addition, the area within which the jet stream centrums were most frequently observed (considered subjectively) was delineated. Finally, major characteristic tracks of the centrums were selected. (It should be remembered that only the more frequent of the characteristic paths were delineated without any attempt to indicate the relative importance of any one track. The characteristic composite tracks are drawn from all jet stream centrums in excess of 50 knots at the 500 mb level and do not distinguish the exceedingly stronger jet stream from the weaker.) The results are presented and discussed with respect to the regional distribution of the jet stream centrums characteristic of each type of blocking system. To make these results more useful, a synoptic catalogue of the dates of the charts utilized in the study of each blocking type is included.

The following remarks briefly summarize some of the more important aspects of the association between jet streams and blocking situations as gleaned from this study.

In general the jet stream configurations in the vicinity of the blocks during the various blocking regimes fit into one of three gross patterns.

1. When the blocks are located south of the 50th parallel, jet stream occurrences are generally limited to the northern periphery of the block.

2. When blocks are located between 50°N and 70°N, jet streams are observed both to the north and south of the blocking area. Because of wave length considerations the jet stream configurations may undergo large latitudinal displacement upstream and downstream of the block.

3. When high pressure centers are located at latitudes north of 70°N, they, in a sense, cease to function as a block and jet streams are reestablished in the mid-latitudes. The jet streams found in high latitudes are few in number and occur principally along the flanks of high cells.

It is not uncommon to have more than one block occurring concurrently, though they may not begin simultaneously. In some cases the block areas may be on opposite sides of the hemisphere but are found most often with a wave length distance approximately 120°. This phenomena occurs most frequently with blocks north of 50°N. In general, however, while a given block in one area may influence the type of pressure systems in other parts of the hemisphere, it does not always determine the precise location of these pressure systems. As a result jet stream tracks in any sector of the Northern Hemisphere may vary considerably during a given or similar blocking regime.

In the section to follow each block type will be discussed in detail with respect to the regional distribution of the jet stream centrums characteristic of the type.

2.2 Winter

2.2.1 Sub-Icelandic Block

(a) Location: 50°N-65°N; 10°W-30°W

The block lies south of Iceland and west of the British Isles (fig. 2.2).

(b) Regional Description

(1) North America

Jet stream centrums are observed principally in the United States in association with well developed troughs. The major channel of jet stream centrums is around the base of the low in the Hudson Bay and Labrador area upstream from the block. A second favored region for the characteristic tracks is in Western and Central United States.

(2) Atlantic and Europe

The majority of jet stream centrums in the Atlantic area are deflected around the northern periphery of the block with a minor incidence south of the block. In the European-Mediterranean sector the favored jet stream trajectory is around the base of a closed cut-off low downstream of the block. The presence of such a system in this area is a characteristic occurrence. The jet stream centrums in the Mediterranean area may extend, on occasion, into part of Southern Russia.

(3) Russia and Siberia

The incidence of jet stream centrums in this area is small with no particular concentration apparent. Those few that do exist are observed over a wide span of latitude. There are virtually no jet stream centrums in Eastern Siberia, in fact, jet streams are not observed in great numbers short of the Coast of China and then primarily south of the 40th parallel.

(4) Japan and the Pacific

The favored location of jet stream centrums in the Western Pacific is mainly over Southern Japan. In fact, the area of greatest incidence throughout the Pacific remains south of the 50th parallel. While jet stream configurations are primarily zonal in the Western Pacific, both meridional and zonal configurations are not uncommon in the Eastern Pacific.

2.2.2 England - North Sea Block

(a) Location: 50°N-70°N; 10°E-10°W

The blocks encompass England, the west coast of Europe and the North Sea (fig. 2.3).

(b) Regional Description

(1) North America

Jet streams are observed over most of the United States and Southern Canada. The principal incidence, however, is found in the northern portion of the United States. In the majority of cases jet streams were evident south of the position of the mean low,

between Hudson Bay and the Davis Straits. The second favored region for jet stream incidence is in Northwestern United States.

(2) Atlantic and Europe

Jet stream tracks are predominantly meridional in the Eastern Atlantic with a pronounced incidence between Iceland and Greenland. A few trajectories penetrate south of the blocking area. In Europe the tracks vary widely in latitude although the majority are located in the vicinity of a closed low southeast of the block.

(3) Russia and Siberia

The majority of jet stream centrums in this sector occur in Southern Russia near the Black Sea.

(4) Japan and the Pacific

A high incidence of jet streams occur over Japan around the base of the mean trough characteristic of this area. The jet stream configurations in the Central Pacific indicate that this region is a favored location for a second block or ridge system which may extend into the Kamchatka region. By and large, jet stream tracks are deflected northward by this ridge although zonal trajectories in the lower middle latitudes are not uncommon.

2.2.3 Mid-Latitude East Atlantic Block

(a) Location: 40°N-50°N; 10°W-30°W

This block area lies off the Coast of France and Spain between the Azores and the British Isles (fig. 2.4).

(b) Regional Description

(1) North America

The jet stream centrums are present principally in the United States, confined primarily to the latitudes south of the Hudson Bay low (fig. 1.3). On occasion, however, when this low is displaced into the Western Atlantic another major trough is present in southwestern United States resulting in a more southerly tra-

jectory of jet stream centrums through this area.

(2) Atlantic and Europe

In the Atlantic the anticyclonic configuration of the jet stream tracks do not, in general, penetrate farther north than Iceland. The low southwest of the blocking area is often well developed as the cyclonic configuration of the tracks indicate. No jet stream centrums were observed south of the block. In Europe the jet stream patterns are mostly meridional with the area of major incidence being associated with a cold cut-off low in the Mediterranean area. On the other hand a substantial incidence of jet streams are observed at the base of a low near Scandinavia.

(3) Russia and Siberia

Jet stream incidence in Russia and Siberia is small. The well defined patterns are usually associated with a ridge at relatively high latitudes, principally over Central Russia.

(4) Japan and the Pacific

With the exception of the Alaskan area the incidence of jet stream centrums throughout the Pacific is confined primarily to latitudes south of 50°N. The orientation of the tracks are principally zonal in the Western Pacific but the configurations in the Eastern Pacific reflect the frequent presence of a ridge varying in location from the Central Pacific to the Gulf of Alaska.

2.2.4 Bay of Biscay Block

(a) Location: 40°N-50°N; 10°E-10°W

This block area encompasses all of France, a small sector off the Coast of France and Northern Spain (fig. 2.5).

(b) Regional Description

(1) North America

During this blocking regime, jet streams were most often observed along the East Coast of the United States. Well developed

troughs can be observed, on occasion, in southwestern United States. Jet streams in Canada were not found with any great frequency though the most characteristic location was north of the Hudson Bay low and south of a high cell at extreme northerly latitudes.

(2) Atlantic and Europe

In general the jet stream tracks are predominantly zonal west of the Central Atlantic area. A pronounced anticyclonic configuration exists over the block from the Central Atlantic to Europe. The area downstream of the block is characterized, in general, by meridional trajectories. Cyclonically curved jet streams are observed around a trough or closed low in the Mediterranean. No characteristic tracks are evident south of the block.

(3) Russia and Siberia

The distribution of the jet stream paths in Russia reflects the characteristic circulation downstream from a trough. Jet streams range over a fairly wide span of latitude but occur with the greatest frequency in the vicinity of 50°N latitude. Siberia, on the other hand, is relatively free of jet stream occurrences. Those jet stream configurations that do exist are associated with the existence of the usually well-developed mean trough in this area.

(4) Japan and the Pacific

The distribution of the jet streams in far Western Pacific reflects the presence of the aforementioned mean trough. In the Eastern Pacific the majority of jet stream configurations indicate that a well developed ridge is often present at high latitudes - though its location may vary from Western Alaska to the Gulf of Alaska. With the presence of such high latitude ridges well developed jet streams are evident around their northern periphery and eastern flank - particularly the latter - but the largest incidence is found to the south of these ridges.

2.2.5 Scandinavian - Baltic Block

(a) Location: 50°N-70°N; 10°E-30°E

This block area encompasses the Scandinavian countries and the Baltic Sea (fig. 2.6).

(b) Regional Description

(1) North America

Although jet stream centrums are found over a wide span of latitude they are most frequently observed in the United States - especially in the area south of the Hudson Bay vortex. Jet stream track configurations reflect the troughs that are characteristically present along both the coasts of the United States.

(2) Atlantic and Europe

In the Western Atlantic two distinct jet stream track configurations are apparent: a multiple system of cyclonically curved jet stream centrums, (one around a low or trough south of Greenland; another around the low latitude trough off the East Coast of the United States) and in addition a zonal pattern near the 50th parallel of latitude. A splitting of jet streams into two distinct branches occurs upstream of the block with the lower branch extending into the Mediterranean and the upper branch extending northward, east of Greenland, into very high latitudes.

(3) Russia and Siberia

A closed low or trough downstream of the block is characteristic of the pressure pattern in Russia. Cyclonically curved jet stream tracks predominate in this area. Siberia is relatively free of jet stream incidence with no characteristic configuration discernible.

(4) Japan and the Pacific

Since four of the six maps in the catalogue were drawn from the maps of the German Weather Service in which no Pacific analyses were available the characteristic configurations in this area are necessarily tentative. On those dates when analysis was available the jet stream configurations indicated the presence of a well-developed ridge or secondary block in the Central Pacific. Although tracks over and under the block are evident,

the former occurs most frequently.

2.2.6 European Russian Block

(a) Location: 50°N-70°N; 30°E-60°E

The block area covers the northeast corner of Russia and Central Europe (fig. 2.7).

(b) Regional Description

(1) North America

Jet streams are observed over a very wide range of latitudes with the characteristic tracks skirting the base of a well-developed Hudson Bay low. The majority of track configurations along the West Coast reflect the occurrence of ridging. Due to this ridging, jet stream incidence in Western Canada is somewhat greater than would otherwise be the case. On occasion, a deep trough or closed low in Southwest United States may be present with resultant cyclonic configurations in jet stream tracks.

(2) Atlantic and Europe

The tracks in the Atlantic area are primarily zonal with the greatest frequency between the 40th and 55th parallels. Near England the paths become divergent - in general, the tracks either continue into Southern Europe around a closed low or recurve sharply to the north around the block. The branching takes place far upstream of the block indicating a high frequency of well-developed lows to the southwest of the block area.

(3) Russia and Siberia

The aforementioned splitting of the tracks continues into Central Russia but thereafter the incidence is confined to a single area in the mid-latitudes. Few jet streams are observed in Siberia itself; in fact the principal region of jet stream occurrence is south of the 50th parallel.

(4) Japan and the Pacific

Jet streams in the Western Pacific are mainly zonal and occur primarily south of the 50th parallel. Pronounced ridging exists off the West Coast of the United States and meridional jet streams penetrate into Alaska.

2.2.7 Ural Block

(a) Location: 50°N-70°N; 60°E-90°E

This block area lies over that part of the Soviet Union that extends eastward from the Ural Mountains and southward from the Kara Sea (fig. 2.8). It represents the eastward limit of strong blocks in Russia.

(b) Regional Description

(1) North America

Two distinct jet stream track configurations are apparent - a pronounced ridge-trough configuration between Northwestern Canada and the East Coast of the United States and a double trough configuration with the presence of a low in Southwestern United States. The Hudson Bay vortex is usually quite well developed.

(2) Atlantic and Europe

In the Atlantic, the characteristic track configurations indicate a pronounced trough-ridge system, the amplitude of which varies considerably. It is quite common to have this block or ridge system in the Eastern Atlantic in addition to a Russian block. A deep trough or cut-off low is often present in Europe.

(3) Russia and Siberia

Jet streams are thrust to very high latitudes over the block area with a pronounced meridional orientation east of the block. While jet streams are observed in association with the trough or low upstream of the block their incidence is not as great as downstream of the block. The low in Siberia is quite well developed and jet streams are prevalent from the eastern flank of the block to Japan, south of the long-wave trough.

(4) Japan and the Pacific

Jet stream tracks are principally zonal in the Western Pacific. The area of major incidence lies south of the 50th parallel over most of the Pacific. Two characteristic configurations are apparent in the Eastern Pacific reflecting the occurrence of both troughs and ridges. The ridges may develop into blocks, the position of which may vary considerably in longitude.

2.2.8 Pacific West Coast Block

(a) Location: 35°N-50°N; 125°W-145°W

This block area lies immediately adjacent to that portion of the West Coast of the United States between Central California and the Canadian Border (fig. 2.9).

(b) Regional Description

(1) North America

Due to the presence of the block off the West Coast of the United States, a deep trough or cold low is usually present in the Southwestern United States with consequent meridional jet stream configurations. In addition, Polar outbreaks from Canada into the Eastern United States are frequent and, as a result, jet streams in this area may occur over a wide range of latitudes. The more northerly jet streams especially are associated with these Arctic outbreaks. In general, the Hudson Bay low is well defined with the characteristic tracks in the Eastern United States and Western Atlantic assuming a rather zonal orientation.

(2) Atlantic and Europe

While a great number of synoptic patterns occur over the Atlantic and Europe the characteristic jet stream track is indicative of ridging in the vicinity of the British Isles, although this ridge may vary in location from Greenland to Scandinavia. When the ridge is over the British Isles the jet stream paths may remain at the upper middle latitudes as far downstream as Russia. The double ridge or block system is quite a common occurrence. On occasion a deep low may be found in the Mediterranean area

with cyclonically curved jet stream paths in evidence.

(3) Russia and Siberia

With the exception of the area immediately downstream of the ridge, most of the jet stream tracks in Russia are predominantly zonal and centered near the 50th parallel. Eastern Siberia is largely free of jet stream incidence.

(4) Japan and the Pacific

Jet streams are largely zonal in character from the coast of Asia to the Central Pacific and found mostly south of the 45th parallel. In the Eastern Pacific the jet stream tracks are deflected around the northern periphery of the block. No characteristic tracks are observed south of the block.

2.2.9 East Central Pacific Block

(a) Location: 35°N-45°N; 145°W-160°W

The block area lies midway between the Hawaiian Islands and the Gulf of Alaska (fig. 2.10).

(b) Regional Description

(1) North America

The area of major jet stream incidence lies within the United States and the characteristic tracks in the Western United States reflect the well-developed trough that is usually present downstream of the block. A second trough or low pressure area is frequently found along, or just off, the East Coast of the United States. Due to the wave length between the two troughs the characteristic tracks are largely zonal.

(2) Atlantic and Europe

The characteristic tracks in the Atlantic reflect the presence of a trough-ridge system. When this ridge is centered near England, jet streams are observed in Scandinavia. It is not uncommon, however, for the ridge to be displaced slightly west of

the British Isles and produce cyclonically curved jet stream tracks around a closed low near Spain. The presence of a second ridge or block in addition to the key block is quite a common occurrence.

(3) Russia and Siberia

Jet stream tracks are observed around lows near the Kara Sea and in the area of the Black Sea. The total incidence, however, is not great. The Siberian area is free of jet stream occurrence.

(4) Japan and the Pacific

The characteristic track configurations illustrate the usual trough-ridge pattern though the amplitudes of the track deformations are not large in comparison with those situations during a high latitude block. No concentration of jet stream tracks are found south of the block.

2.2.10 Sub-Aleutian Block

(a) Location: 45°N-55°N; 145°W-180°

The block area lies south of the Aleutian Islands and east of the Gulf of Alaska (fig. 2.11).

(b) Regional Description

(1) North America

Jet streams are found principally in the United States. The Hudson Bay vortex is well developed although displaced to the east of its normal position. Eastern Canada and Greenland are relatively free of jet stream incidence. In Western Canada, however, Arctic jet streams are not uncommon. The majority of tracks in the United States are zonal and the configurations indicate the presence of well-developed troughs off the West and East Coasts - particularly the former.

(2) Atlantic and Europe

Two track configurations are apparent; a quasi-zonal flow near 45°N and a pronounced trough-ridge sequence with the axis of the ridge varying from England to Scandinavia. On occasion this ridge may develop into a blocking system. Well developed low pressure systems near Iceland are a common feature.

(3) Russia and Siberia

The greatest incidence of jet streams is confined to Western Russia and the configurations reflect the presence of the well-developed trough that is usually downstream of the blocking ridge in Scandinavia. The characteristic orientation is decidedly meridional. Few jet streams are apparent in Siberia and their configurations suggest the presence of weak ridges.

(4) Japan and the Pacific

Jet streams are found over a wide span of latitude in the Western Pacific, indicative of periodic cold outbreaks in this area. The track configurations illustrate the trough-ridge-trough sequence with the majority of jet streams observed along the northern periphery of the block. With well-defined blocks of this type cut-off cold lows are often found off the California Coast with consequent cyclonic jet stream configurations. This block on occasion may be of exceptional amplitude. A second block near England is a frequent characteristic of this type.

2.2.11 Bering Sea - Western Alaska Block

(a) Location: 55°N-70°N; 145°W-180°

The block area lies in the region from the Aleutian Islands to Northern Alaska (fig. 2.12).

(b) Regional Description

(1) North America

Due to the extreme northerly position of this block there is a fairly high incidence of jet stream tracks in far Western Canada. The well developed vortex that is sometimes located in Western Canada and other times east of the Hudson Bay region, contri-

butes to the high incidence of jet streams that are observed in the United States - particularly in the northern portion. Although numerous pressure patterns occur in eastern North America, the characteristic tracks indicate a tendency for a trough just off the East Coast of the United States. Zonal configurations, however, may also be observed.

(2) Atlantic and Europe

The characteristic jet stream configurations in the Atlantic reflect the eastward drift of lows across the Atlantic. In many cases a well-defined ridge or second block occurs in Northern Europe and jet streams are deflected into very high latitudes. In general, jet streams may be observed over a wide area in Europe with no preferred locale.

(3) Russia and Siberia

Jet streams in this sector are found over a wide range of latitudes though most frequently in Western Russia. By and large the typical configuration is cyclonic in association with transitory lows in the area. Eastern Russia and Siberia do not exhibit any great frequency of jet stream occurrence.

(4) Japan and the Pacific

Of the nine cases in the catalogue three were selected from the German Weather Service and hence do not include a Pacific analysis. A pronounced trough-ridge configuration is present in the characteristic tracks. However, when the block is near the extremity of the area jet streams may occur to the south of the block.

2.2.12 Kamchatka Block

(a) Location: 50°N-70°N; 140°W-180°

The block area encompasses Eastern Siberia, the Kamchatka Peninsula and the Western Bering Sea (fig. 2.13).

(b) Regional Description

(1) North America

A higher incidence of jet streams are observed in Canada than

in some of the previous cases though the greatest incidence is in the United States. The Hudson Bay vortex is displaced north and west of its usual location. The characteristic paths are found in two latitudinal zones although the majority of the tracks reflect the presence of a well-defined trough in the eastern portion of the United States.

(2) Atlantic and Europe

In this region the characteristic jet stream tracks are predominantly zonal. Although the tracks may be deflected around a block or ridge near England, they frequently continue south of the block at lower latitudes into Southern Russia. Well developed jet streams are usually found in Southern Europe around the low, downstream of the block.

(3) Russia and Siberia

No appreciable frequency of jet streams is observed in Central Russia and Siberia. The majority of jet stream tracks terminate in Western Russia. The influence of the Kamchatka block is apparent in Eastern Siberia with meridional configurations on the western flank of the block - albeit infrequently.

(4) Japan and the Pacific

Since the block area is located in rather high latitudes, the mid-latitude westerlies remain relatively undisturbed. In fact the majority of tracks are found south of the block throughout most of the Pacific - primarily between the 30th and 40th parallels. In the Eastern Pacific, however, jet stream tracks are observed at both high and middle latitudes. The incidence of jet streams is higher on the eastern flank of the block than on the western flank. Jet streams along the eastern flank are often associated with well-developed low systems near the Gulf of Alaska. An area of weak ridging is frequently observed in the Eastern Pacific - particularly when the block is located on the western extremity of the block area.

2.2.13 Beaufort Sea Block

(a) Location: 70°N-80°N; 145°W-160°E

The block area lies over the Arctic Ocean and the Beaufort Sea

extending from Alaska to Eastern Siberia (fig. 2.14). It is the most northerly of Pacific block areas.

(b) Regional Description

(1) North America

The block area lies in the upper western extremity of North America and while jet streams are observed in Far Western Canada their location varies considerably. By and large jet stream tracks are observed only along the eastern flank of the block but this conclusion may be due in part to lack of data in Siberia. In general, the Hudson Bay low is well delineated and jet streams are most frequent near the Canadian border and the Central United States. A well-developed trough is often found along or near the East Coast of the United States.

(2) Atlantic and Europe

Jet streams are found over a wide latitudinal span with a marked tendency for occurrence near the 50th parallel. The track configurations reflect the presence of both a trough-ridge sequence in the Central Atlantic-Europe area and quasi-zonal conditions.

(3) Russia and Siberia

The majority of jet streams in Russia were observed between the 45th and 60th parallels. In Siberia, jet streams are absent north of the 50th parallel and it is only in the vicinity of the Coast of Asia that the incidence becomes appreciable and then mainly south of the 50th parallel. The jet stream configurations reflect the presence of a trough in Central Russia and the mean trough near Japan.

(4) Japan and the Pacific

Jet streams are observed in the middle latitudes throughout the Pacific Ocean, south of a series of well developed lows in the Aleutians and Gulf of Alaska. The track configurations are mainly zonal with weak ridging being evident near the West Coast of the United States.

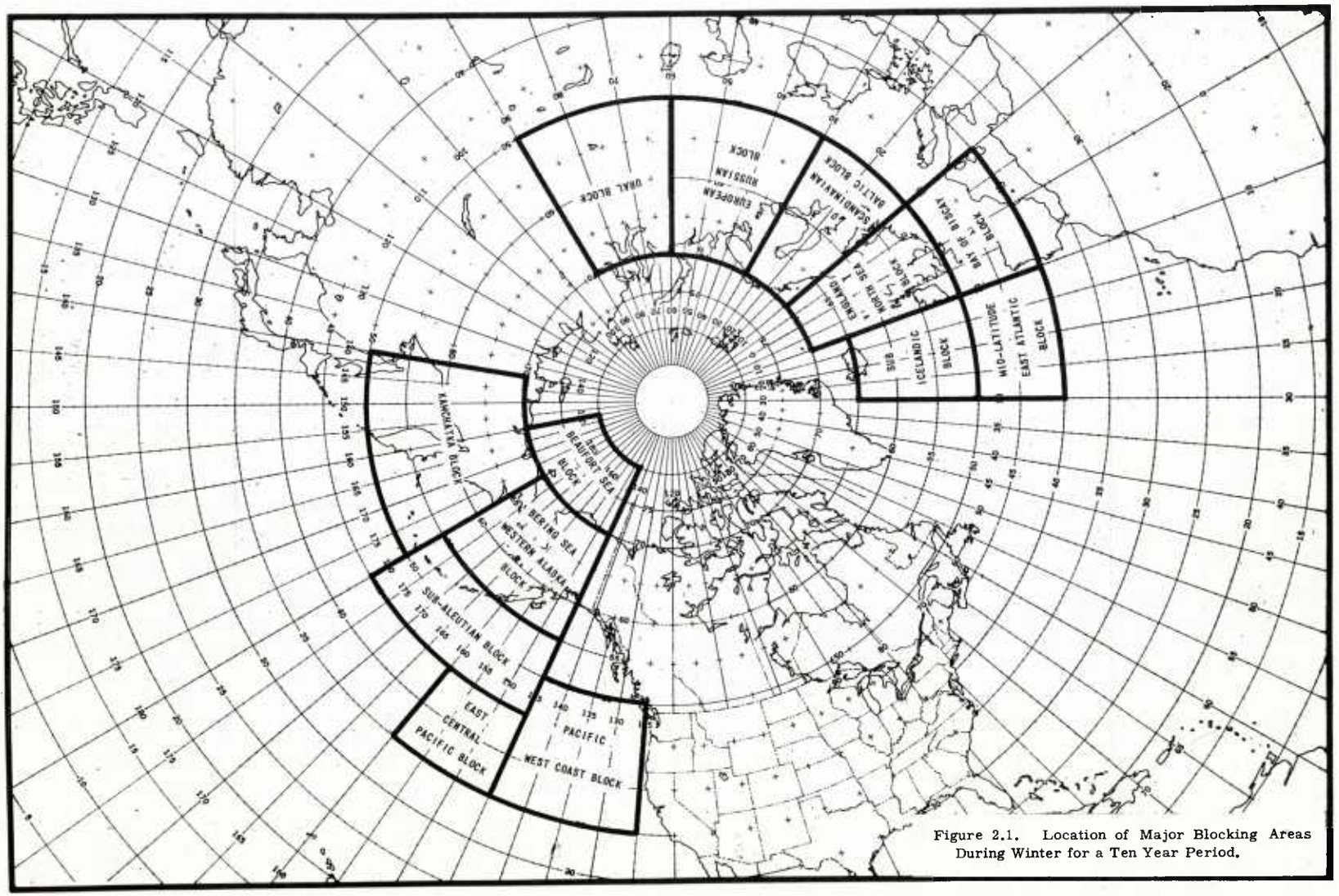

Figure 2.1. Location of Major Blocking Areas During Winter for a Ten Year Period.

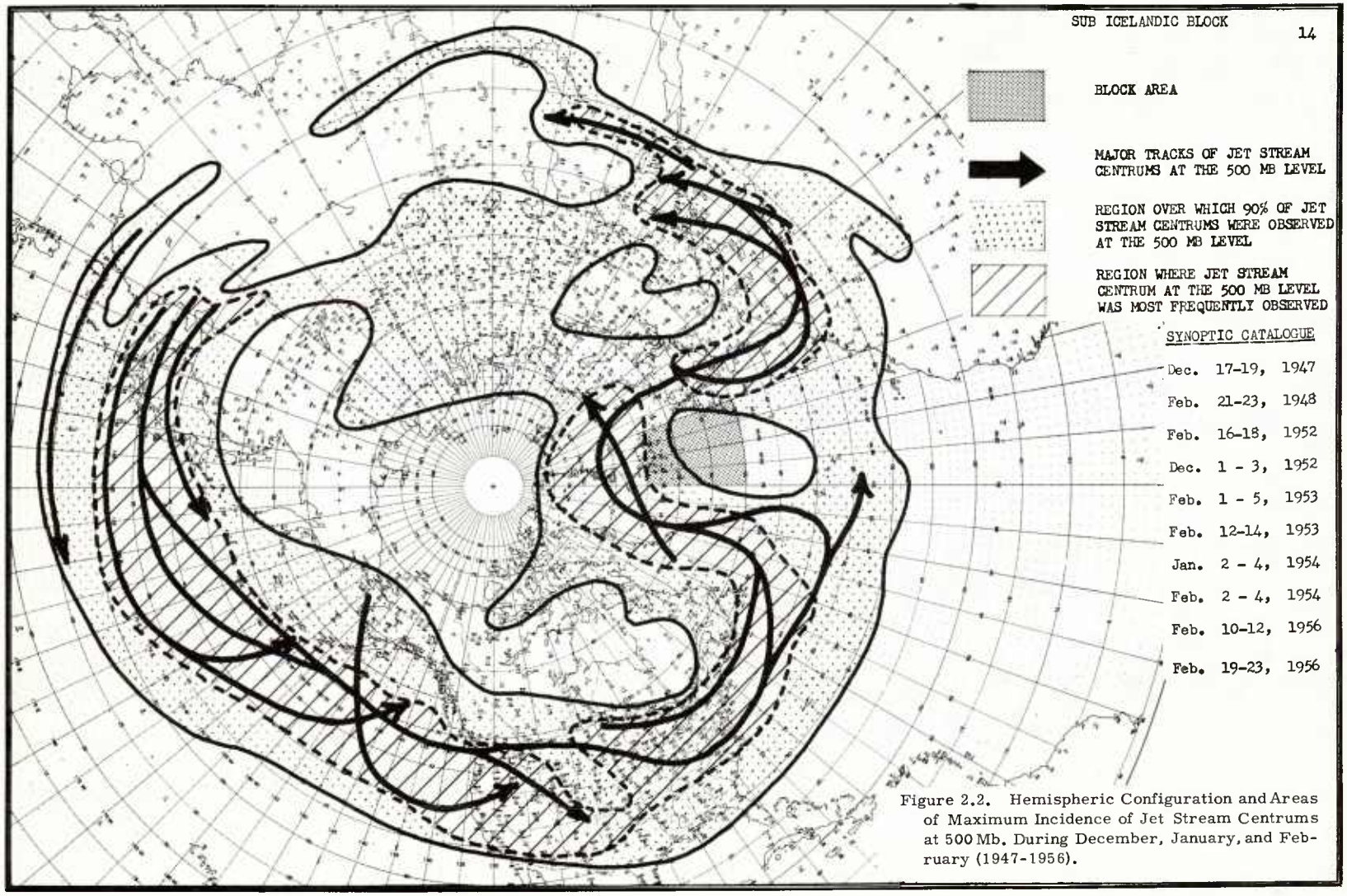

Figure 2.2. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

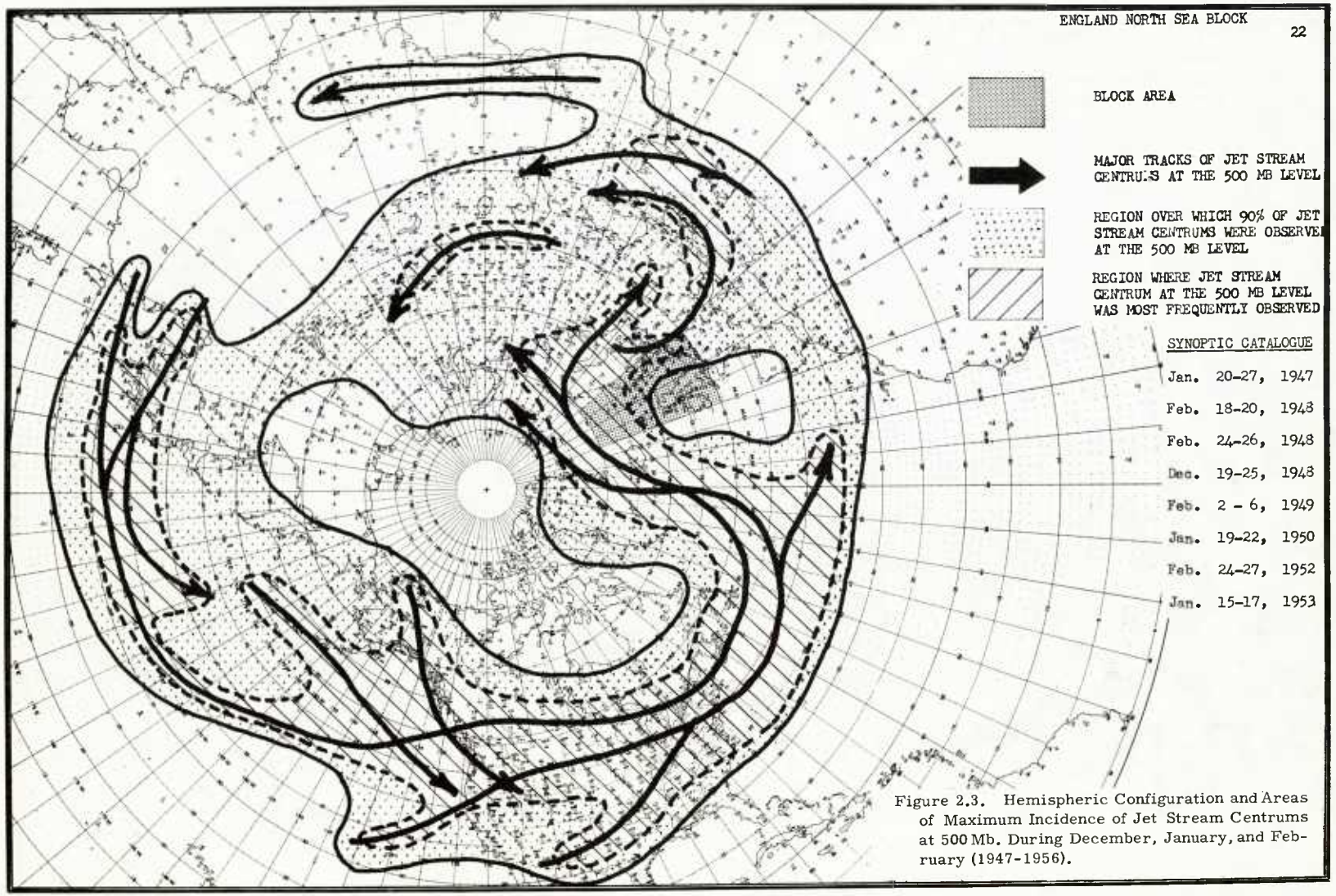

Figure 2.3. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

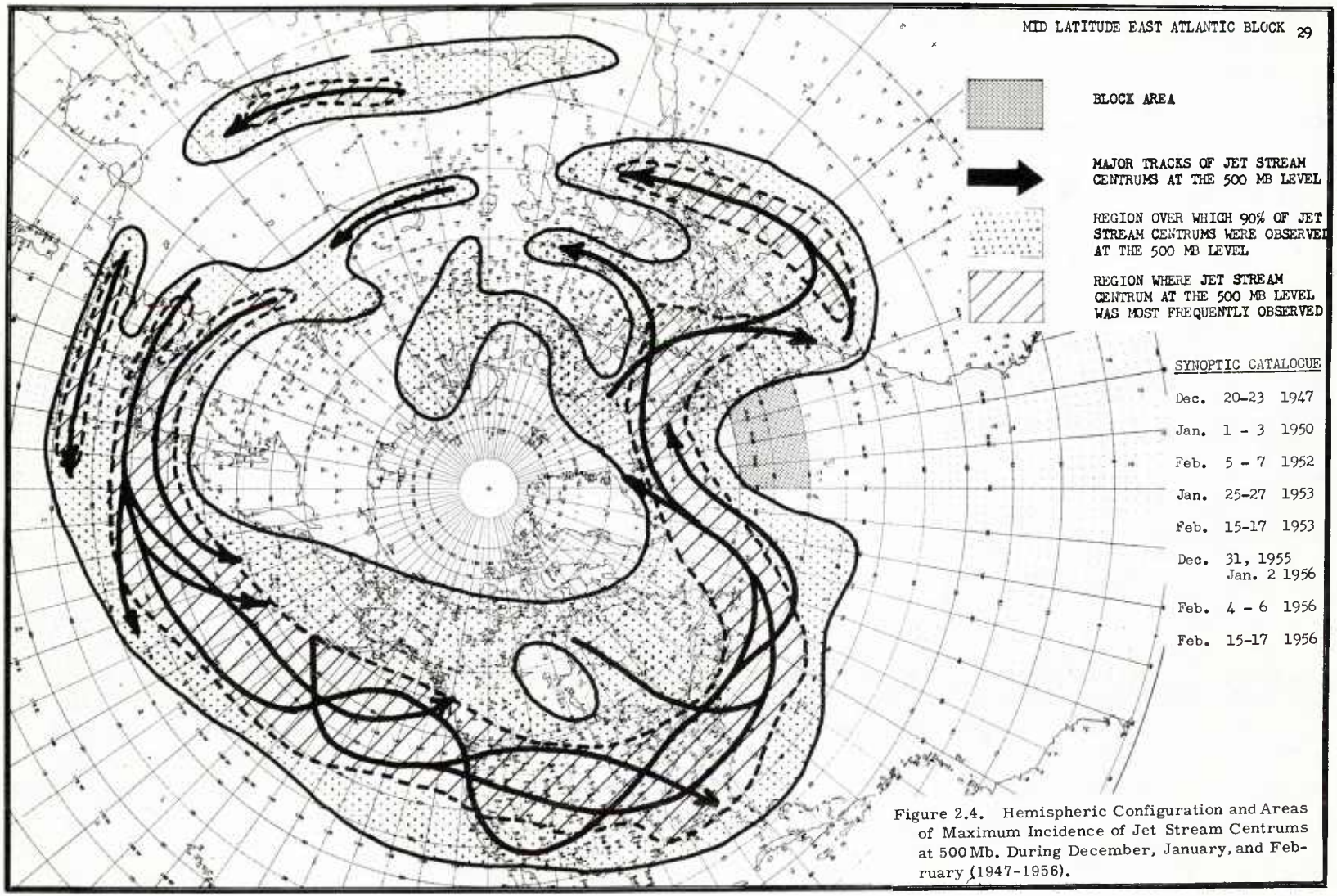

Figure 2.4. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

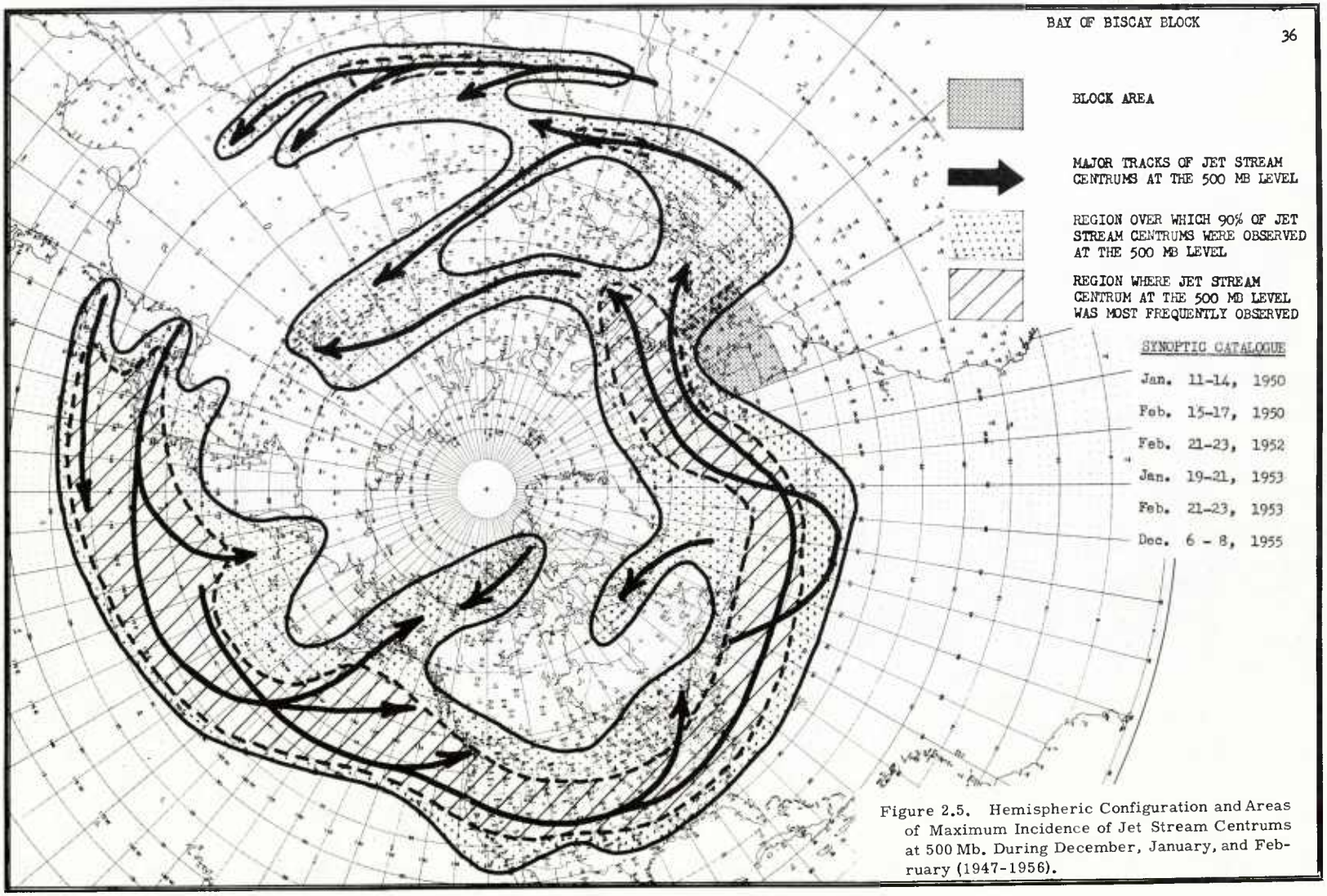

Figure 2.5. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

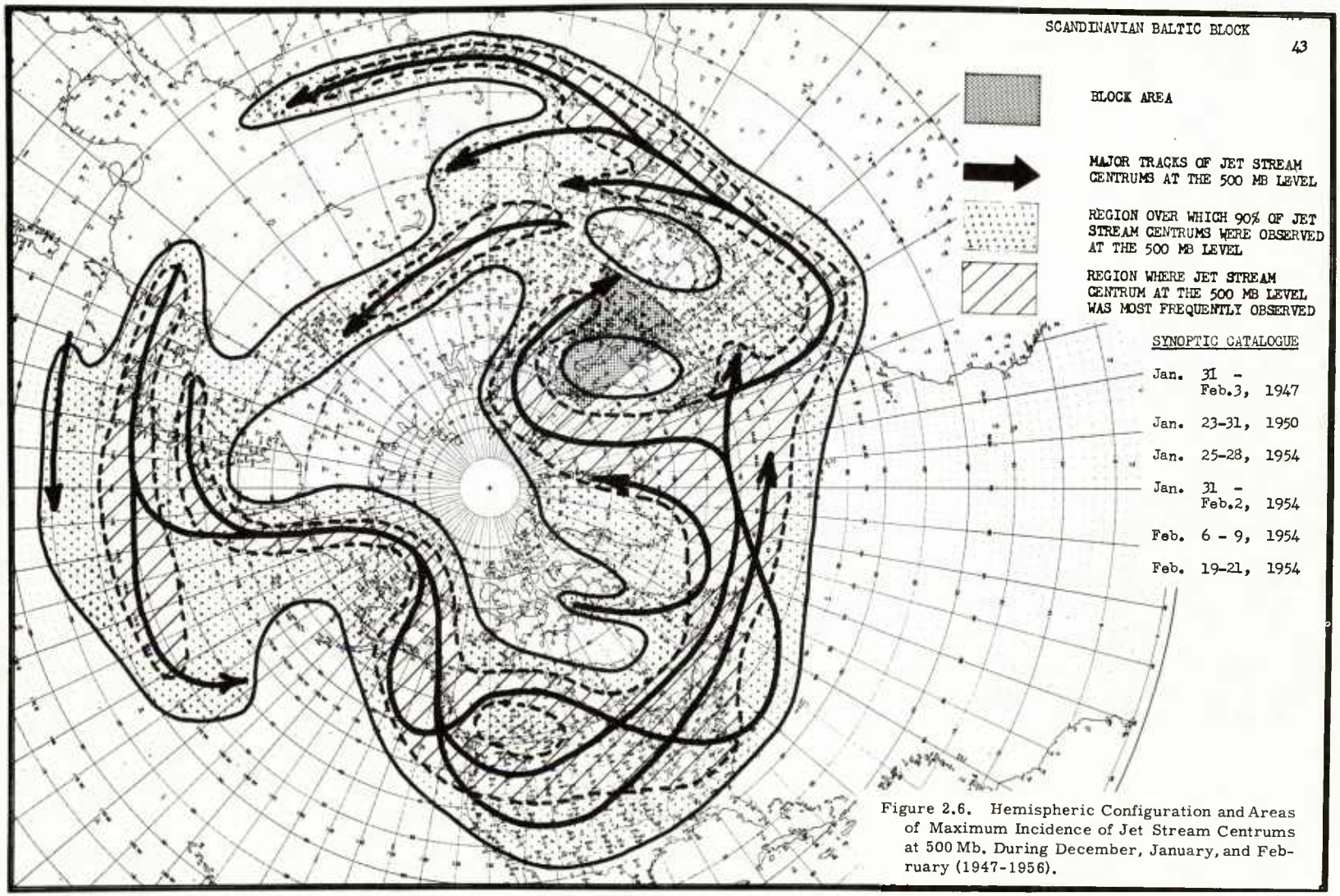

Figure 2.6. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

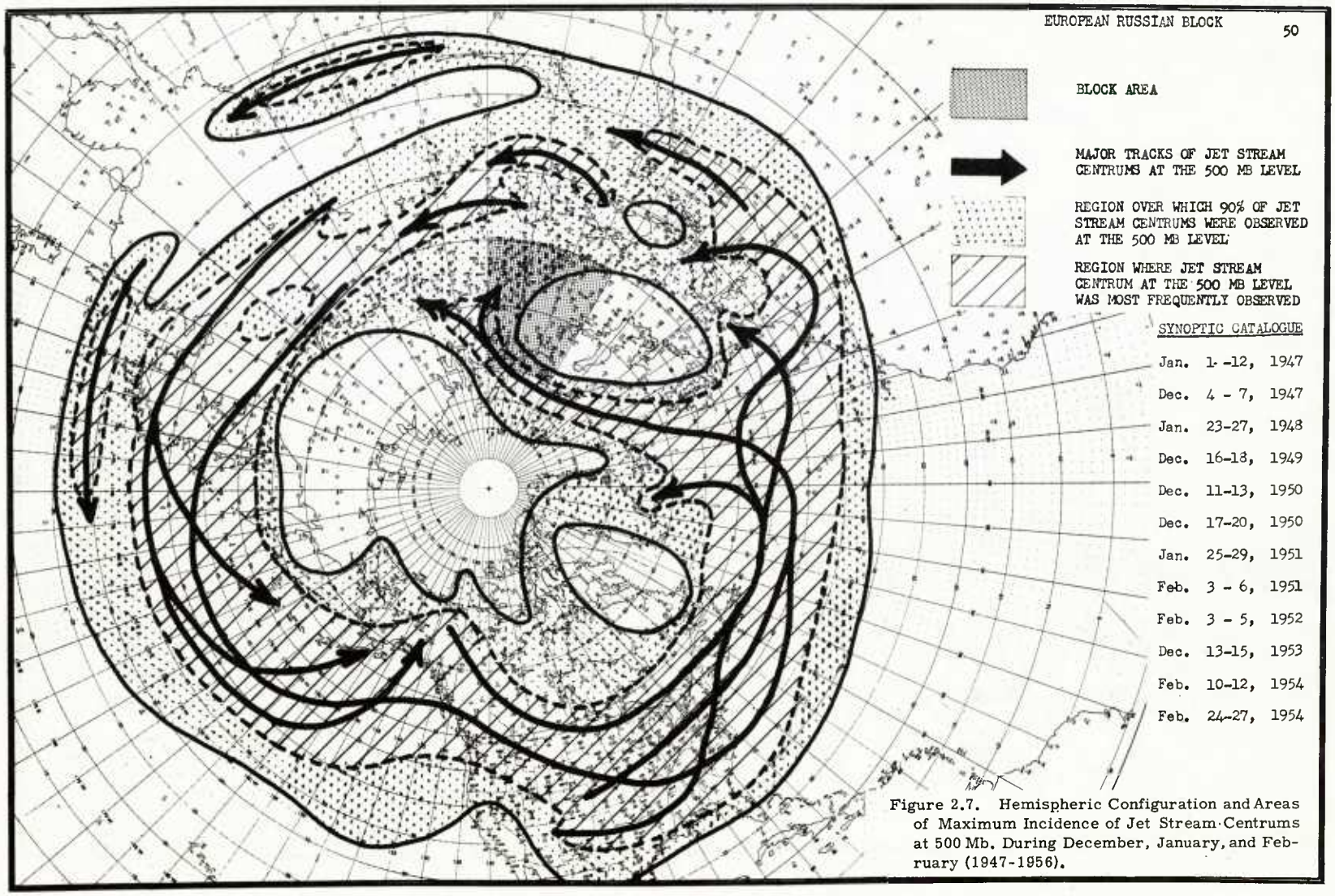

Figure 2.7. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

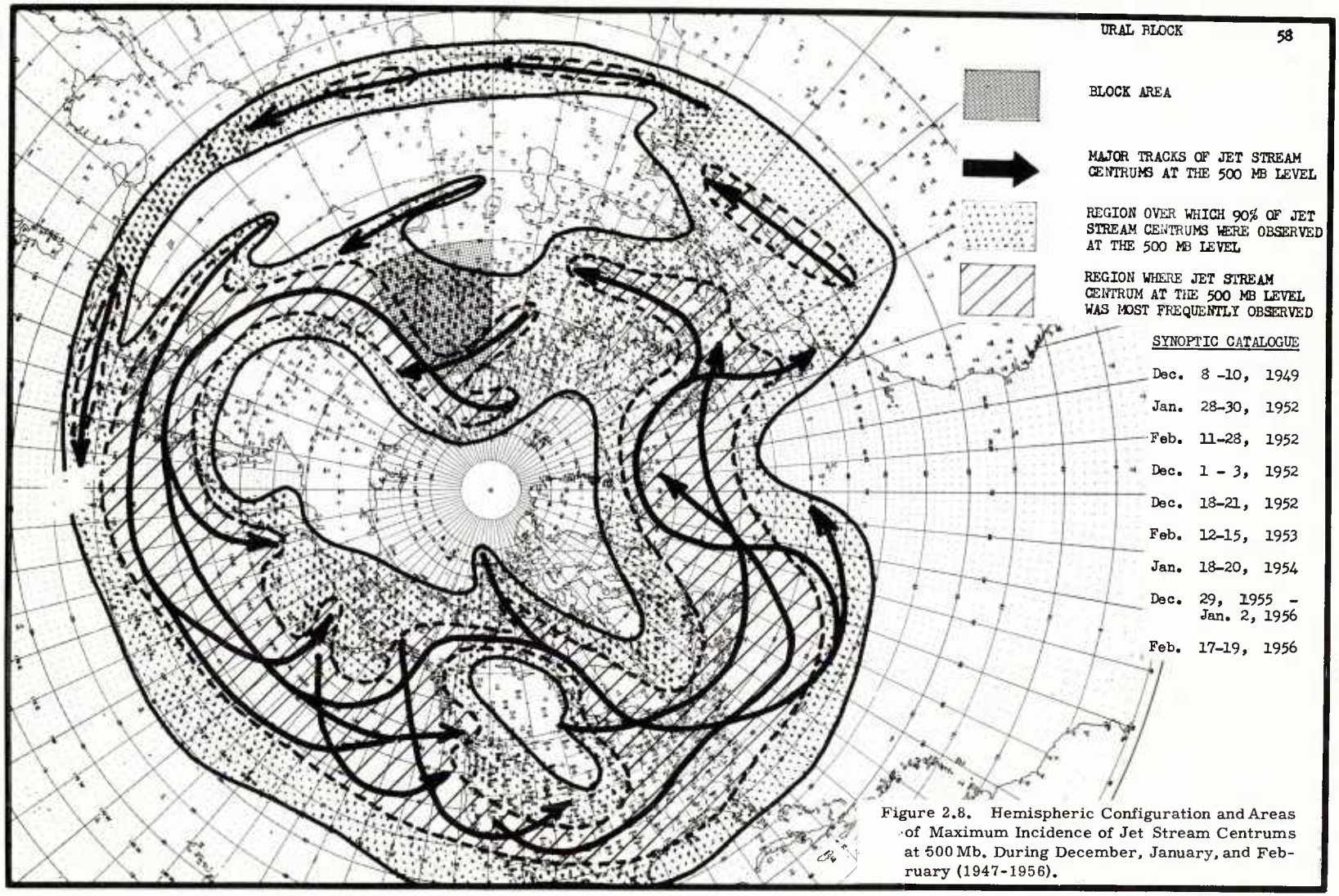

Figure 2.8. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

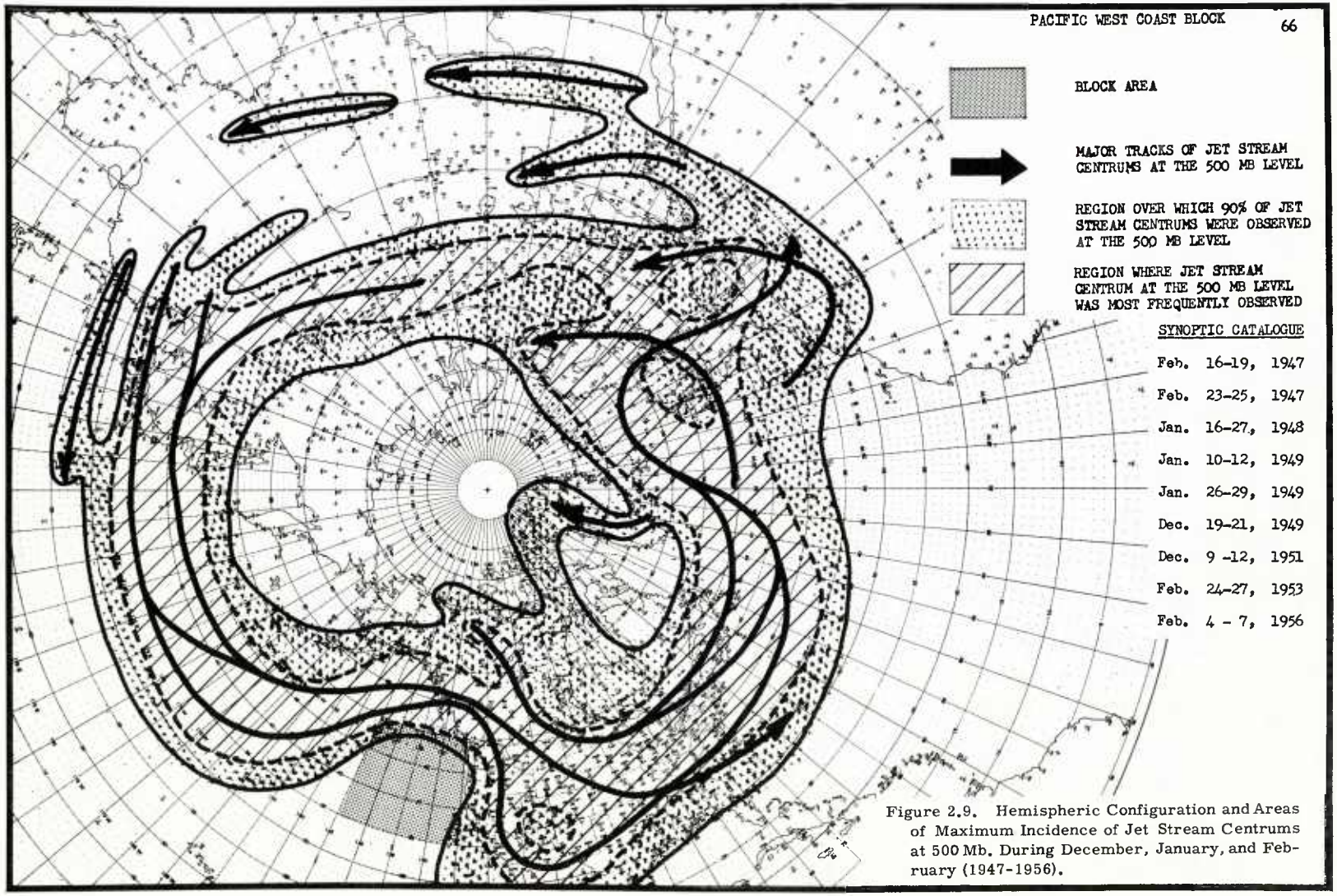

Figure 2.9. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

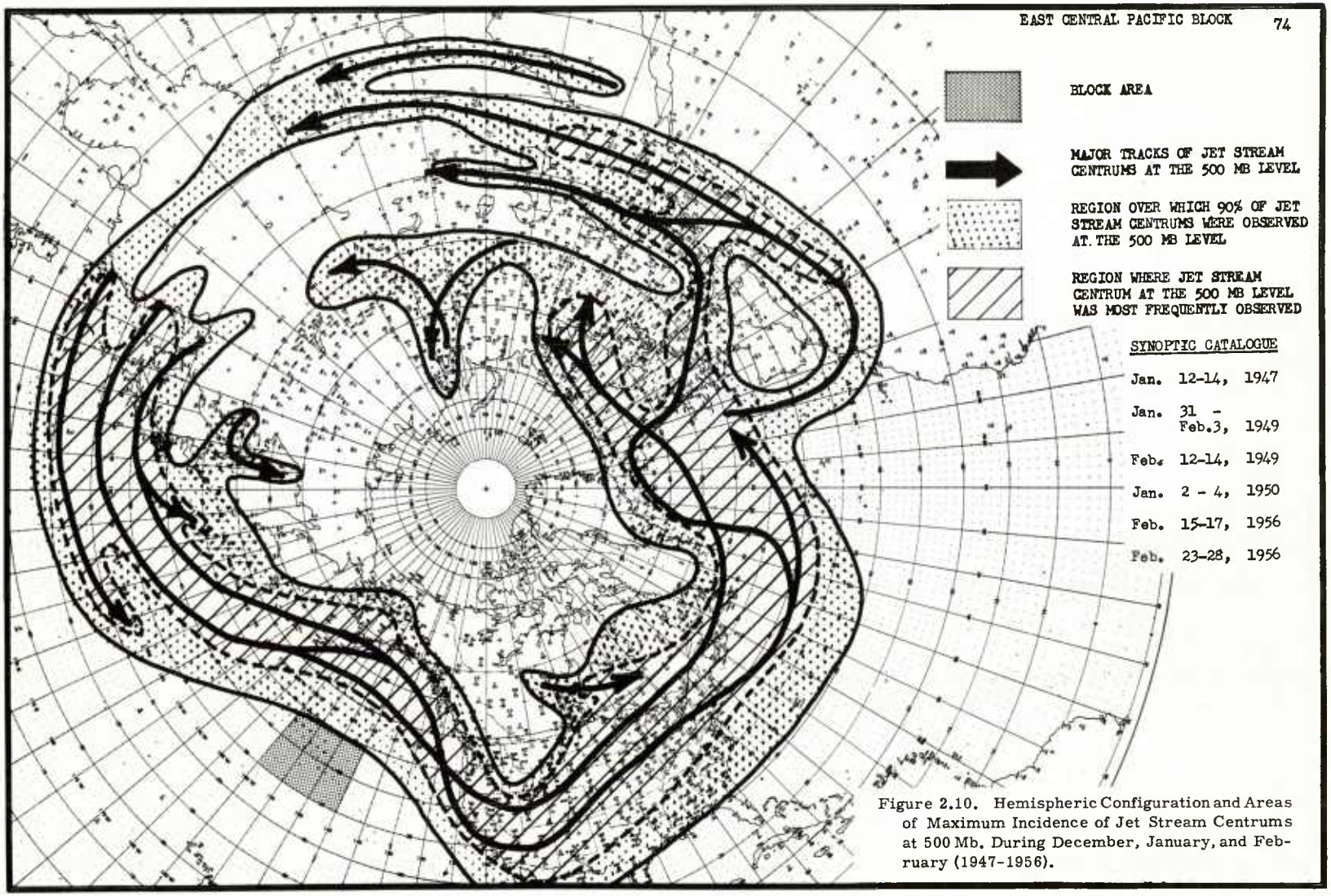

Figure 2.10. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

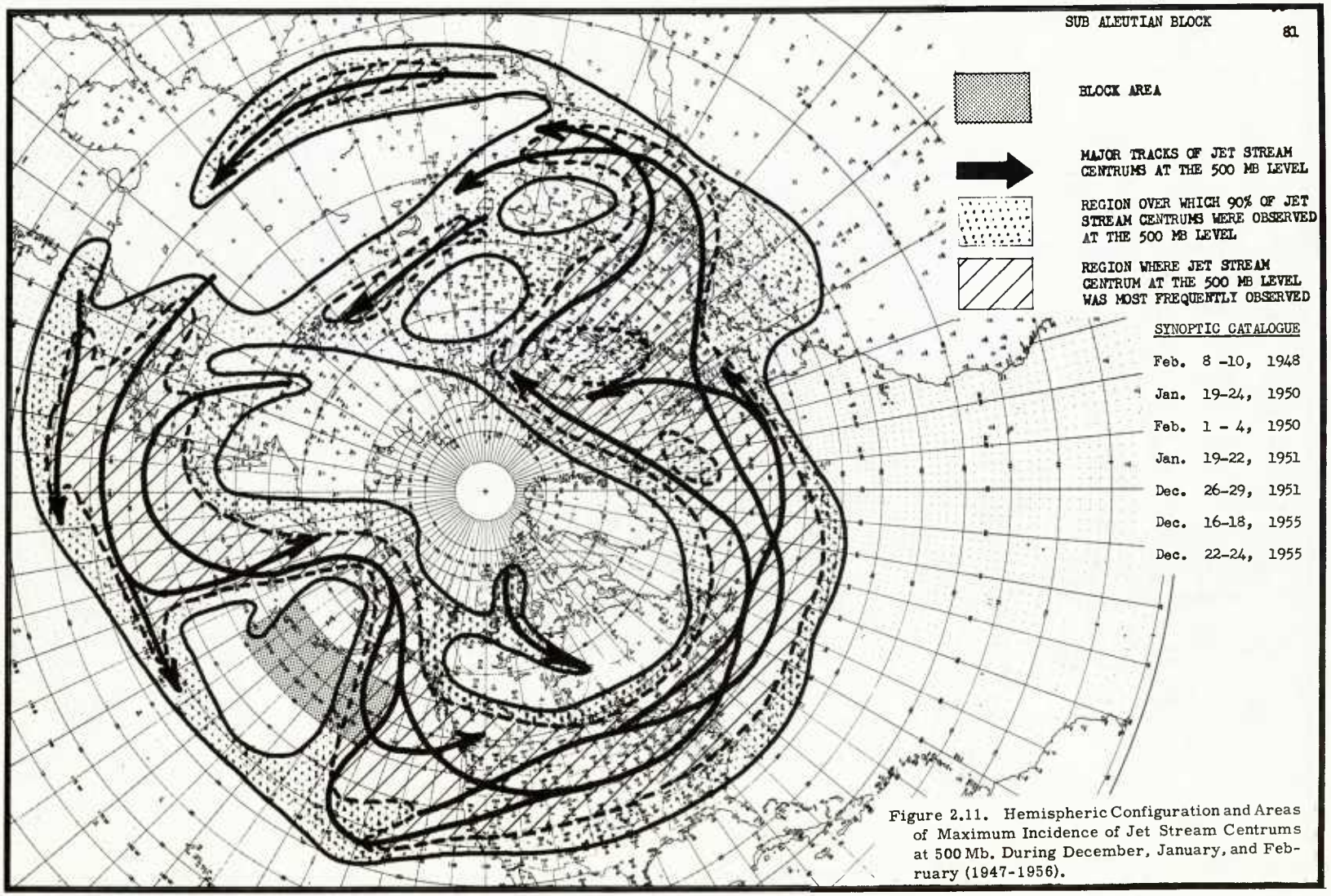

Figure 2.11. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

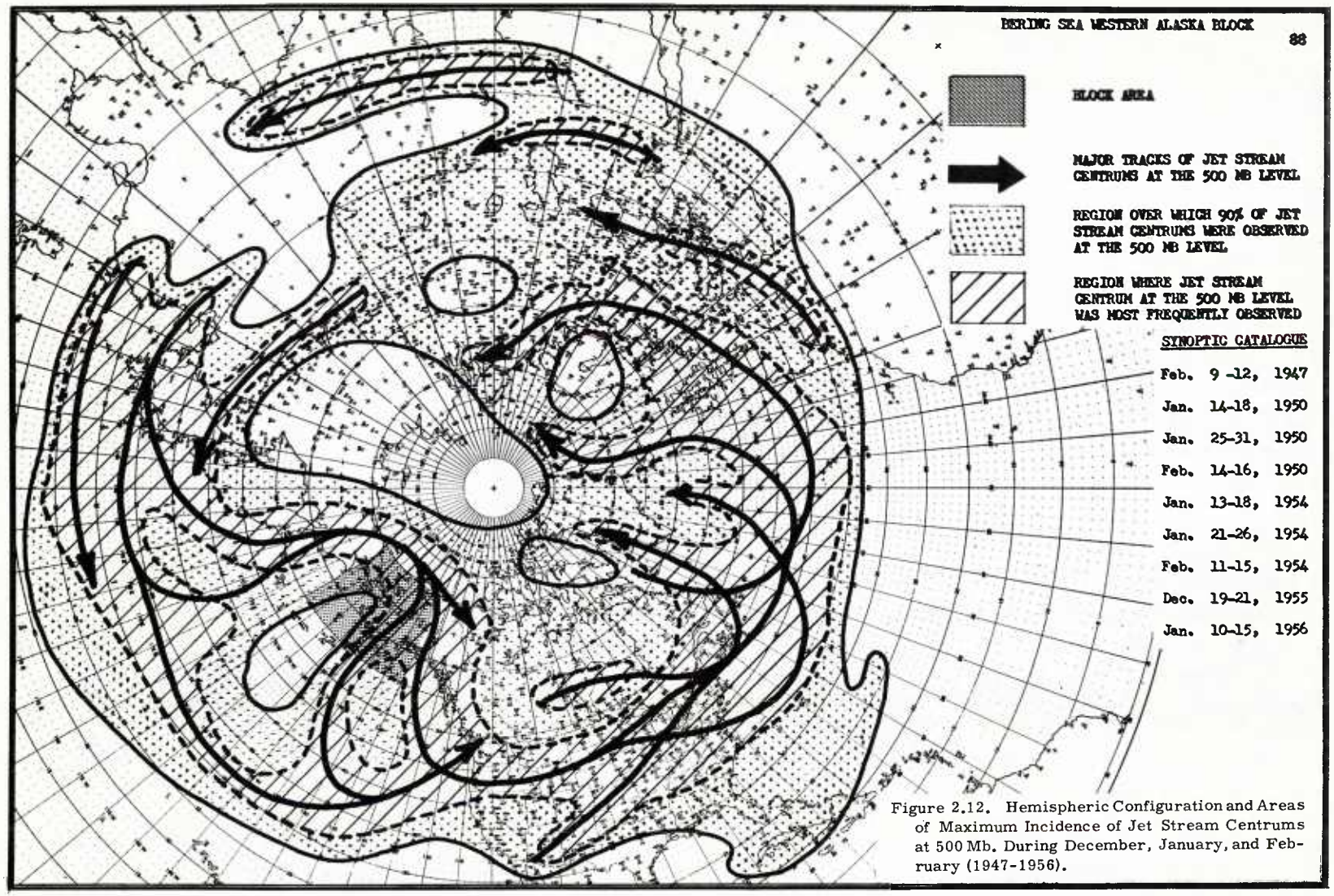

Figure 2.12. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

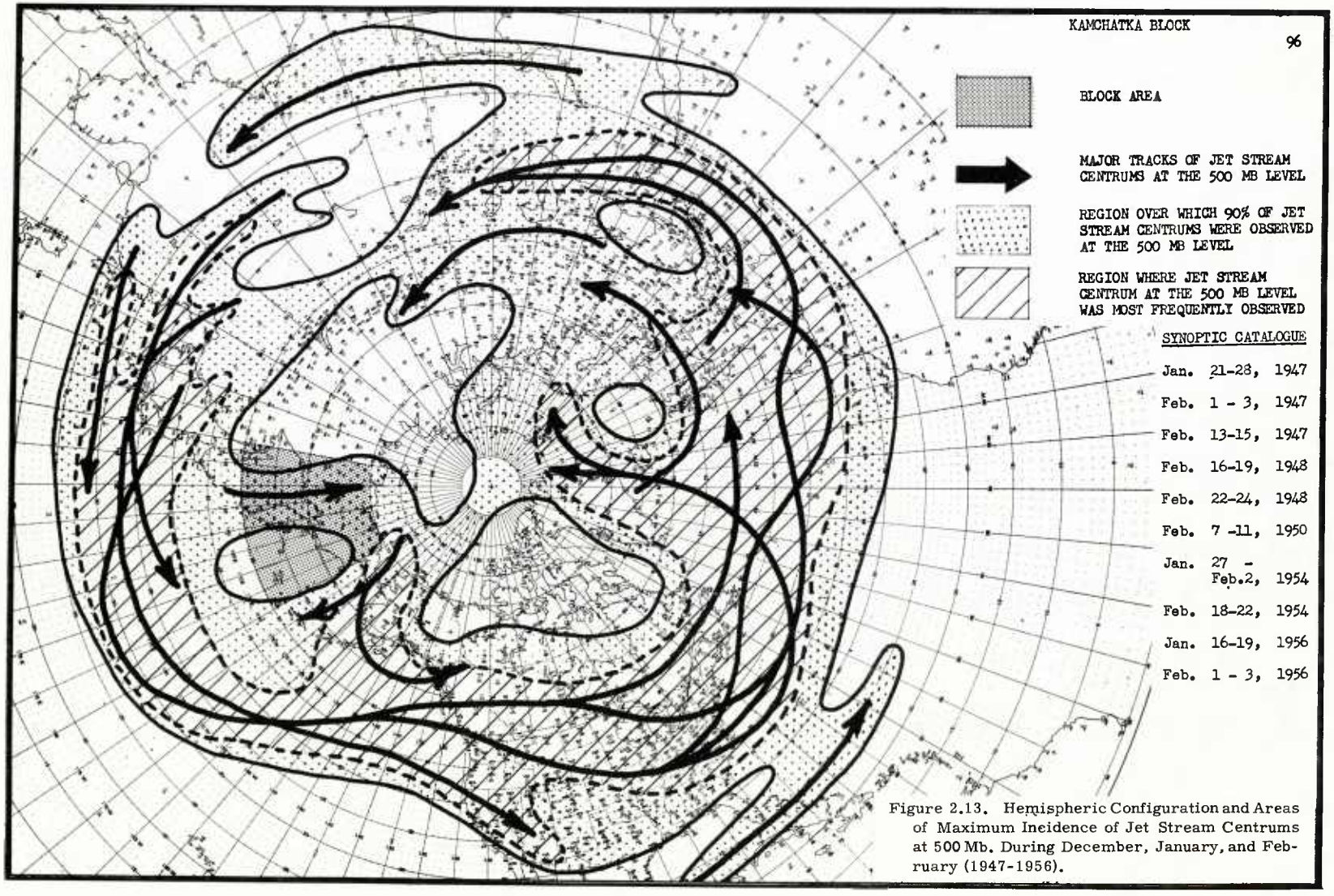

Figure 2.13. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

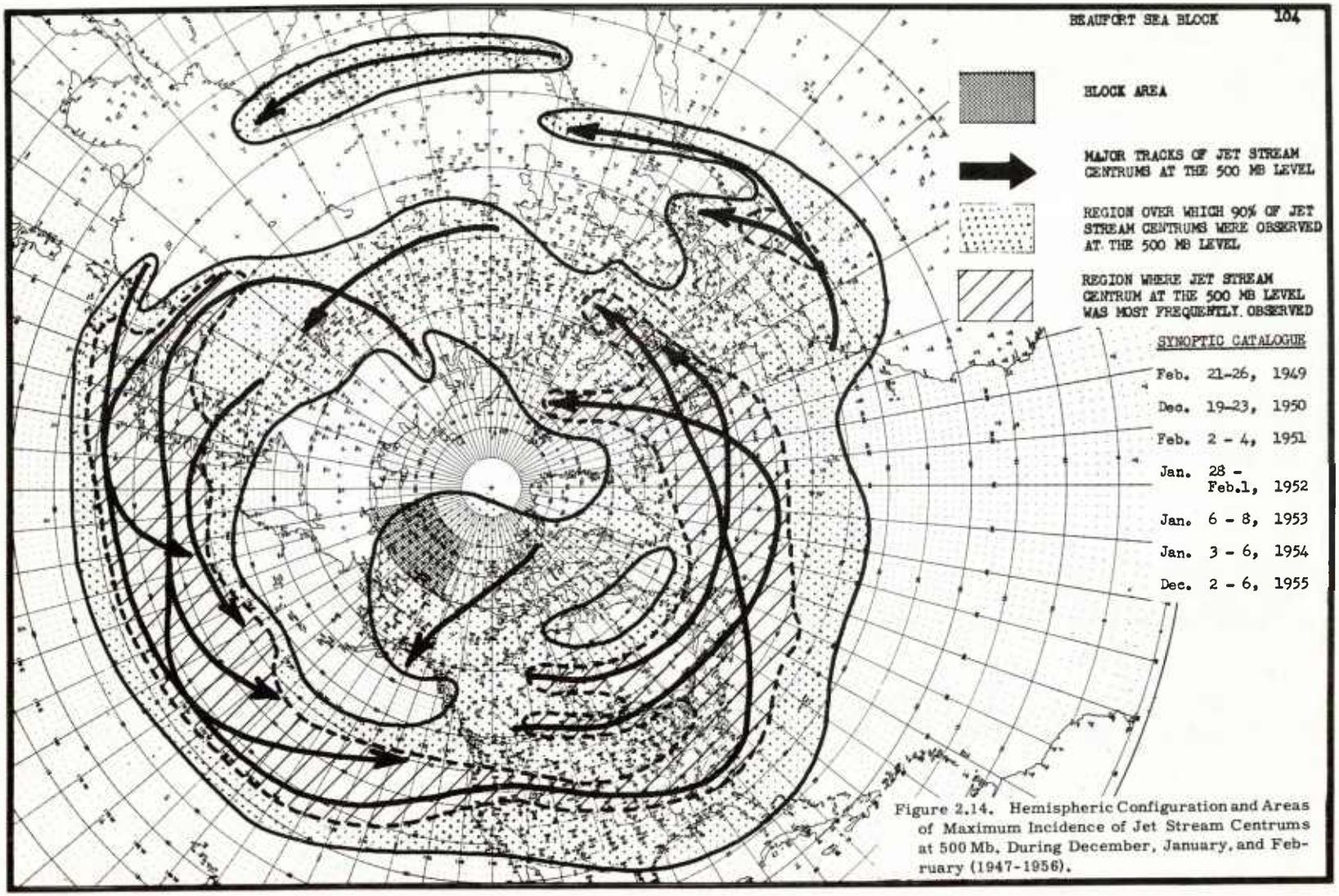

Figure 2.14. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During December, January, and February (1947-1956).

2.3 Spring

2.3.1 Greenland - Newfoundland Block

(a) Location: 45°N-70°N; 75°W-35°W

The block area is centered over the Davis Straits, extending from the east shore of Hudson Bay to the east coast of Greenland (fig. 2.16). It extends northward from Newfoundland to Baffin Bay.

(b) Regional Description

(1) North America

This sector lies immediately upstream of the blocking area and, consequently, the distribution of jet stream incidence is influenced by the amplitude and location of the blocking high. The majority of jet stream occurrences are found within the United States, usually in association with pronounced ridging off the west coast. On the other hand, when strong ridging is noted in western Canada, jet stream incidence is restricted to Canada or the northern United States. During the latter circumstance the trough upstream of the block is quite shallow, being centered along the east coast of the United States. Jet streams are absent in the Hudson Bay area, as a rule, being observed in this area in only one case during the course of this investigation.

(2) Atlantic and Europe

Blocking highs fluctuate considerably in longitude from one case to another during this type. The catalogue contains a slight bias toward locations in the eastern half of the blocking area, which accounts for the appearance of jet streams within the western portion of the blocking area on figure 2.16. Despite the fluctuation in longitude the deformations in the jet stream are quite pronounced, both upstream and downstream of the block. In all cases in the catalogue a well defined cyclonic configuration is present to the south or southwest of the block. Trapped lows southwest of the blocking high are quite common. In all cases penetrations of jet streams into high latitudes over the top of the block are observed. In addition, jet streams are observed undercutting the block, though, on any single day, not often extending

completely across the Atlantic. Large amplitude troughs, downstream of the block, result in jet stream occurrences as far south as Spain. The downstream trough varies in location from 30°W to 10°E. Note the multiplicity of tracks in this area on figure 2.16. Jet streams are observed in significant number over North Africa.

(3) Russia and Siberia

In Russia, as in Europe, jet streams occurred over a wide range of latitude. The configurations indicate two different synoptic regimes - one a ridge of considerable amplitude which thrusts jet streams to a high latitude and the other, a trough system which may be located in eastern Europe or the Urals. Jet streams are largely absent in Siberia itself with the major incidence being confined to Manchuria and Japan. Jet stream configurations in this area are primarily zonal.

(4) Japan and the Pacific

Jet streams are found in significant number over the Pacific, being concentrated primarily between the 35th and 50th parallels. Their configurations in the western Pacific are largely indicative of pronounced trough development. Ridging is evident in the central or eastern Pacific. When strong ridging occurs in the central Pacific cyclonic jet stream configurations may be observed in the Gulf of Alaska.

2.3.2 England - Iceland Block

(a) Location: 45°N-75°N; 35°W-5°E

The block area covers the North Atlantic extending from the eastern periphery of Greenland to Norway (fig. 2.17). It extends northward from the southern coast of England to the Arctic Circle.

(b) Regional Description

(1) North America

Due to the relatively large number of cases in the catalogue and the variety of synoptic patterns contained therein, jet streams

were observed over a wide range of latitudes but tended to occur most frequently within the United States. The configurations, in general, reflect the occurrence of cold air outbreaks from Canada accompanied by strong ridging in the Gulf of Alaska or western Canada. As a rule, the focal point of the outbreak is in the eastern United States or the western Atlantic but, on occasion, a westward shift in the pattern may result. During periods of cold air outbreaks it is not unusual to see two jet streams across the continent, even at the 500 mb level - one jet stream across the central or southern United States and one near or north of the Canadian border. A second prominent pattern is the appearance of a deep trough or closed low just off the west coast with ridging in the central United States. During these situations the jet streams tend to be found in Canada, usually with pronounced anticyclonic deformation. Of course, variations of both of these patterns may occur.

(2) Atlantic and Europe

Because of the presence of the block area in this region, the amplitudes of the jet stream are usually quite large. The area of incidences in the Western Atlantic is particularly wide, indicating a great variation in the location and development of the trough upstream of the block throughout the sample. In general, the cyclonic configuration of the jet stream is quite marked just upstream of the block. On some occasions two distinct jet stream tracks may be noted, especially if the upstream trough possesses extreme amplitude. Blocks in this area are usually quite well developed and are found with greater frequency than in any other section of the Northern Hemisphere during this season. Jet streams are found along the northern periphery of the block in all cases. Anticyclonic configurations are quite pronounced, particularly if the block is located at the northern extremity of the block area. Jet streams south of the block, at the 500 mb level, are not found in every case, however. Such occurrences are usually associated with a trapped low center.

In Europe the location, frequency and intensity of the jet stream regime is determined by the upstream block. The jet stream tracks are largely meridional, particularly in northern Europe, reflecting the tendency for large amplitude troughs to develop in this region. An interesting facet is the tendency for a marked

divergence of the jet stream tracks near the northeastern portion of the block area. One track continues across Russia at high latitudes while the other plunges southward in response to the downstream trough. This is observed in most of the cases. Jet stream incidence in the Mediterranean is fairly high in the months of March and April. The configurations are largely zonal and often extend into Arabia and Northern India. In May the incidence is less because the necessary gradients at the 500 mb level are established less often, though jet streams may exist at higher levels.

(3) Russia and Siberia

This sector is characterized by the presence of the downstream trough of the blocking regime plus the occurrence of a second major low or trough in the Siberian region. A great variety in deformations occur but the incidence, for the most part, is concentrated in the higher latitudes. With cold air outbreaks from Siberia the jet streams tend to occur in the Manchurian area. No jet streams were observed around the Arctic rim, at least in the Siberian sector.

(4) Japan and the Pacific

This region is characterized by the appearance of jet streams over a fairly large span of altitudes, indicating a great variation in the latitudinal position of pressure systems. A seasonal factor is noted here since the southernmost penetrations are observed most often in March. In the main, the configurations indicate the presence of troughing in the western Pacific. The synoptic patterns in the central and eastern Pacific are much more varied. Jet stream incidences are most marked between the 40th and 60th parallels. When ridging is present in the eastern Pacific, the major jet stream incidence is found in Alaska or the Gulf of Alaska. On those occasions when cold air penetrations from Siberia progress across the Pacific, jet stream incidence is greatest in the middle latitudes. In those cases the jet streams usually have extended zonal orientations.

2.3.3 European - Scandinavian Block

(a) Location: 45°N-70°N; 5°E-40°E

The block area lies over Europe, Scandinavia, Finland and European Russia as far as Moscow (fig. 2.18). It extends northward from the Italian border to the Barents Sea.

(b) Regional Description

(1) North America

Jet streams in this sector tend to occur with three distinct pressure patterns. One typical pattern with meridional jet streams results from the penetration of cold air from Canada into the eastern United States, accompanied by ridging in western Canada. Another typical pattern exhibits a deep trough or closed low in southwestern United States with a high incidence of jet streams around the low. The jet streams in both Canada and the United States may be quite intense. A third pattern involves a pronounced zonal flow with a track across the central United States and another along the Mexican border. From the foregoing it is obvious that jet streams may vary over a wide range of latitudes, particularly in western United States and Canada.

(2) Atlantic and Europe

Because of wave length considerations the greater portion of the Atlantic just upstream of the block is characterized by the frequent occurrence of jet streams at rather low latitudes in association with deep penetrations of cold air. The longitude of the upstream trough varies from Europe to the central Atlantic. On occasion a trapped low southwest of the block area may occur, with a consequent fragmentation of the jet stream at the 500 mb level. As a rule, jet streams are well marked around the base of the upstream trough. The fact that the area of major incidence lies well upstream from the block area results from the fact that the majority of cases in this type tended to occur in the eastern half of the block area. Well developed jet streams are observed along the northern periphery of the block area in every case. Jet streams are observed in the Mediterranean to a marked degree, particularly in early spring.

(3) Russia and Siberia

The downstream trough of the blocking system lies in this

sector. It is usually of large amplitude resulting in decided cyclonic configurations in the jet streams. The area of major incidence lies between the 40th and 50th parallels. Jet streams are also common south of the Caspian Sea in the vicinity of Iran and northern India. The orientations, however, are usually zonal. In eastern Russia, jet streams are most often observed between the 40th and 50th parallels near Manchuria and northern China. The configurations indicate weak ridging or zonal flow prior to the occurrence of a deep trough near 140°E, particularly in March when the cold outbreaks of winter are still in evidence. On occasion two jet stream areas may be observed, one near 50°N and a second near 35°N.

(4) Japan and the Pacific

In the Pacific two principal configurations are noted; one, a more or less zonal flow across the entire Pacific and another, which culminates in ridging in the eastern Pacific. In both synoptic patterns the characteristic presence of a trough or low near Japan results in jet stream incidence being observed within a relatively limited area as compared to the eastern Pacific (see fig. 2.18).

2.3.4 Ural Block

(a) Location: 45°N-70°N; 40°E-80°E

The block area is centered over the Ural Mountains and extends eastwards from Moscow to the Altai Mountains (fig. 2.19). It extends northwards from the Caspian Sea to the Kara Sea.

(b) Regional Description

(1) North America

Jet streams tend to concentrate in southwestern United States, whereas in the eastern United States and Canada they are rather widely distributed. This distribution results from two distinct synoptic patterns; one is characterized by the presence of a deep trough in southwestern United States and a low just southeast of Hudson Bay. During this pattern, jet stream activity is found around the trough extending through the Great Lakes area to the

Atlantic, with a second area of activity around the Hudson Bay low. A third area may be observed along the Mexican border. A variant of this type occurs when the deep trough in southwestern United States occurs somewhat more inland. During both these patterns jet stream activity around the Hudson Bay low may be quite pronounced. Another important type is characterized by the presence of a deep trough or closed low center just east of the Great Lakes. The principal jet stream activity is confined to the middle and high latitudes, though jet streams across the southern United States may still be observed. It is apparent that in this sector the location of jet stream activity is dependent upon the degree of ridging off the west coast of the United States and the development and progression of cold air outbreaks from Canada.

(2) Atlantic and Europe

While there is considerable variation in the synoptic patterns observed in this region, two basic patterns are outstanding. In one type the cold air penetrates into the area of Greenland and a large cyclonic vortex is noted over nearly all of the north Atlantic. Two jet stream tracks are evident; one around the vortex and the second, somewhat further south, which continues around a deep trough or low southwest of the block. In the second main type, the cold air penetrates southward to Newfoundland or the Great Lakes region. Pronounced ridging is evident in the central Atlantic, culminating in a deep trough over Europe just upstream of the block. In those cases where the block is located on the western periphery of the block area, the ridging may be shifted into the western Atlantic. Ordinarily, double jet stream systems may be observed around the major lows and troughs in both these types. Because of the latitude of the block the upstream trough is often of exceptional amplitude. Significant jet stream occurrence is evident over North Africa.

(3) Russia and Siberia

Inasmuch as the blocks in this area are of the progressive type (having moved in from Europe), a considerable variation in location of jet stream activity is noted, particularly when the catalogue is considered in the aggregate. The configurations, however, are quite similar, with jet stream penetrations over the block in nearly all cases. The downstream trough is usually well

marked and of considerable amplitude. Jet stream incidence is most frequent between the 40th and 50th parallels. Further into Siberia, the incidence of jet stream activity falls off materially. In addition to the trough downstream of the block, another major trough is found in the longitudes of Japan, particularly in March and April. Jet streams extend from the block area, across northern Manchuria, into this latter trough area. On occasion double jet stream systems are noted.

(4) Japan and the Pacific

Due to the strong development of the trough near Japan, jet streams are thrust into the lower middle latitudes in the western Pacific. The longitude of the trough may vary considerably, ranging from Korea to the central Pacific. On occasion the synoptic pattern is such that a trough is observed off the west coast of the United States, with consequent cyclonic deformations in the jet stream.

2.3.5 Kamchatkan Block

(a) Location: 60°N-75°N; 140°E-170°W

The block area lies over easternmost Siberia extending from the Okhotsk Sea to the Bering Straits (fig. 2.20). It extends northward from the Kamchatka Peninsula to the Laptev Sea.

(b) Regional Description

(1) North America

The area of major jet stream incidence is located in the western or central United States as well as in southeastern Canada. Jet stream configurations reflect the presence of two principal pressure patterns. One pattern is characterized by the occurrence of a well defined trough in the western United States, with jet streams extending eastward into the Atlantic. With this pattern another jet stream area is evident around a low in eastern Canada or the Davis Straits area. A second basic synoptic pattern is characterized by a trough near the Great Lakes.

(2) Atlantic and Europe

The two areas of major incidence observed in Canada and the United States continue into the Atlantic, merging into a single area in the central Atlantic. In some instances the jet stream tracks through the southern United States continue into the Atlantic and culminate in a trough off Europe. They then may recurve northward around a ridge centered near England. No jet stream activity was noted in the lower latitudes. Although the catalogue is small, it is believed that these types are typical. In most cases jet streams are observed in the Mediterranean or North Africa in addition to jet stream activity over Europe.

(3) Russia and Siberia

The areas of major incidence are found in Russia and along the Arabia-India region. In western Russia, jet stream configurations may reflect the presence of the trough just downstream from the ridging over England. On the other hand, jet stream activity may extend in a more or less continuous fashion across northern Russia into Siberia, with anticyclonic curvature. In Siberia, jet stream activity is conditioned by the degree of development of the cyclonic vortex upstream of the block area. Most of the jet streams are found across northern Manchuria, extending into the Japanese area. In some cases jet streams were evident around the block. Lack of data undoubtedly resulted in an unrealistically low estimate of frequency.

(4) Japan and the Pacific

Because of the high latitude of the block area, the westerlies are reestablished south of the block. In the western Pacific the jet stream concentration is mainly between the 30th and 45th parallels. In the eastern Pacific the greatest frequency is found between the 45th and 60th parallels. The jet stream configurations in the western Pacific reflect the occurrence of lows south of the block. In nearly all cases the synoptic pattern in the eastern Pacific is one of ridging. In some instances a trough development in the Gulf of Alaska may be noted. In these cases the blocking high is located in the eastern portion of the blocking area.

2.3.6 Alaskan Block

(a) Location: 50°N-70°N; 165°W-125°W

The block area lies over Alaska and the Gulf of Alaska (fig. 2.21). It extends eastward from the Bering Straits to the Yukon and northward from the Canadian border to the Arctic Ocean.

(b) Regional Description

(1) North America

Inasmuch as this region lies immediately downstream of the key block area, the location and incidence of jet streams is directly influenced by variations of the block itself. In the majority of cases a well-defined trough is situated in the Hudson Bay area, along with a weak trough in southwestern United States. In general, ridging is found near the east coast of the United States. Two main jet stream tracks are observed - one extending from the northern periphery of the block, around the Hudson Bay vortex to Newfoundland and the second extending across central or southern United States. When blocking occurs in the extreme western portion of the block area, the downstream trough may be located in the western United States and undergo strong development. A single jet stream track is then observed. In this case a ridge develops to the north of the vortex, with pronounced anticyclonic deformations in the jet stream.

(2) Atlantic and Europe

Jet stream configurations in this sector are closely associated with the trajectory of cold air from Canada. With stagnation of the vortex in the Hudson Bay area, the jet stream tracks in the high latitudes reflect the presence of weak ridging near Greenland and troughing in northern Europe. Jet streams in the lower middle latitudes continue more or less zonally across the Atlantic into a well defined trough off Spain. On occasion, ridging in the central or eastern Atlantic is of such amplitude that the southern jet stream area merges with the northern one. The trough off Spain still remains highly developed. When cold air from Canada penetrates into the eastern Atlantic, the trough-ridge-trough pattern is displaced considerably eastward. In the majority of these cases, ridging over Europe is the predominant pattern, with the principal area of jet stream incidence being located over England and Scandinavia. Jet stream activity at the 500 mb level is also observed in North Africa in the majority of cases, particularly

during March and April.

(3) Russia and Siberia

The location of jet stream activity is influenced by the pattern over Europe. In those cases where ridging is found over Europe a well-defined trough is located near the Urals, with the majority of jet streams being observed north of the 40th parallel. With a well defined trough over Europe a marked ridging is located near the Urals and jet streams are thrust into rather high latitudes. Downstream, in Siberia, the jet streams plunge southward and are found with greatest frequency along the Manchurian border. South of Russia the second jet stream area that is observed is a continuation of the North African activity.

(4) Japan and the Pacific

The location and incidence of jet streams in this sector are influenced to a marked degree by the location and strength of cold air intrusions upstream of the block. In general the trough upstream of the block is centered in the western Pacific. Double jet stream configurations are evident around the base of this trough. In the block area these jet streams tend to diverge, with one progressing over the block and the other penetrating under a vortex south of the block.

2.3.7 Mid-Latitude - East Pacific Block

(a) Location: 35°N-50°N; 160°W-130°W

The block area lies immediately south of the Gulf of Alaska, midway between the Aleutian Islands and the Hawaiian Islands (fig. 2.22). It extends eastward almost to the Pacific West Coast.

(b) Regional Description

(1) North America

Jet streams in this sector are largely confined to the United States and far western Canada. Several basic patterns are noted. One pattern is characterized by the presence of a well-developed trough in western or central United States and ridging near New-

foundland. During this regime a double jet stream is commonly observed, with one jet stream track describing the ridge-trough-ridge configuration in the higher latitudes and the other extending more or less zonally across the southern United States. A variation in this pattern occurs when the deep trough is located in the eastern United States, with the downstream ridge being found in the eastern Atlantic. A third pattern is characterized by troughing in the southwest United States and in the western Atlantic, with marked ridging in the central United States. The double jet stream system that was so well established in the other patterns is not so clear-cut in this type.

(2) Atlantic and Europe

With the presence of ridging near Newfoundland, the downstream trough is located near England, though the amplitude may vary considerably. One jet stream area is observed in high latitudes, while a second extends into the Atlantic from the United States at fairly low latitudes. In neither case does this jet stream activity extend beyond the central Atlantic. In those cases with deep troughing off the east coast of the United States, a pronounced ridge development is found in the eastern Atlantic or Europe. Jet streams are thrust into high latitudes over the ridge or block. When the latter pattern occurs, jet streams may be observed around a vortex south of the block. In Europe a trough of varying development, depending upon the upstream ridge, is the main feature. The majority of jet streams, as a consequence, are meridional. Such meridional penetrations may extend as far south as the Mediterranean, particularly when trapped lows are developed near Spain. A second jet stream system may be present in North Africa

(3) Russia and Siberia

The principal areas of jet stream incidence in this sector are found in northern Russia and southern Siberia. In general, the jet stream configurations reflect the presence of ridging in central Russia, although the amplitude is usually not large. Troughing into the Black Sea area is also quite common. Jet stream activity is observed with both these patterns but tends to be fragmented at the 500 mb level particularly around the base of the trough. Jet streams are fairly continuous in the Manchurian area,

and extend from the ridge to the base of a well-developed trough near Japan.

(4) Japan and the Pacific

The area of major incidence lies across Japan and the Gulf of Alaska. In all cases, jet streams are active around the base of the trough near Japan as well as over the block in the eastern Pacific. Double jet stream systems are observed over Japan and the western Pacific in nearly all the cases. Usually the southernmost jet stream system extends part way around a trapped low southwest of the block while the northern system extends in a more continuous manner over the top of the block. None of the jet streams were observed to completely undercut the block.

2.3.8 Canadian Block

(a) Location: 55°N-75°N; 125°W-75°W

The block area lies over central Canada and extends from the Canadian Rockies to just east of Hudson Bay (fig. 2.23). It extends northward from Hudson Bay to the Beaufort Sea.

(b) Regional Description

(1) North America

Due to the location of the block area, cold air outbreaks tend to penetrate into the eastern United States. Note the high incidence of jet streams in this area (fig. 2.23). In addition, low pressure systems from the Pacific progress across the United States to the south of the block. Thus two main jet stream tracks are established, which come into phase around a deep trough near the east coast. Neither jet stream system is necessarily continuous across North America at the 500 mb level. The catalogue, however, contains a bias towards the warmer months (April and May) during which jet streams may be less developed at the 500 mb level. This is particularly true with respect to jet stream activity north of the block.

(2) Atlantic and Europe

In essence, two distinct configurations are evident. In one type the overall pattern is characterized by the presence of a trough or vortex off the east coast of the United States and again near England, with weak ridging in the central Atlantic. A double jet stream system may exist in the vicinity of the troughs, with the southernmost system extending across the Atlantic. The second configuration is characterized by the trough off the east coast of the United States, though somewhat further east, and pronounced ridging in the eastern Atlantic. Jet streams are deflected to the north of the ridge.

(3) Russia and Siberia

The majority of jet streams are located over northern Russia and Manchuria. Whenever a well developed trough is found in Europe, jet stream activity over a ridge in western Russia is usually quite marked. These systems, of course, are a continuation of those over Europe. Ridging is predominant in central Russia but the location varies with the location and development of the upstream trough. Low pressure systems in the Siberian Arctic may result in cyclonically curved jet streams of limited extent. Lack of data, however, often precludes their observance. Jet stream activity near Manchuria is much more common and, generally, penetrates into the Japanese Islands.

(4) Japan and the Pacific

Jet stream incidence is largely confined to the area between the 35th and 55th parallels. In most of the cases the western Pacific is characterized by a trough or vortex. Double jet stream systems are not uncommon. Moreover, these jet streams seem to be limited in extent at the 500 mb level, tending to disappear prior to the Gulf of Alaska. When the block is located in the western portion of the block area a trapped low is observed south of the block. When a trough-ridge-trough pattern is observed, with the ridging being located near the central Pacific, jet streams tend to be limited to the base of the troughs.

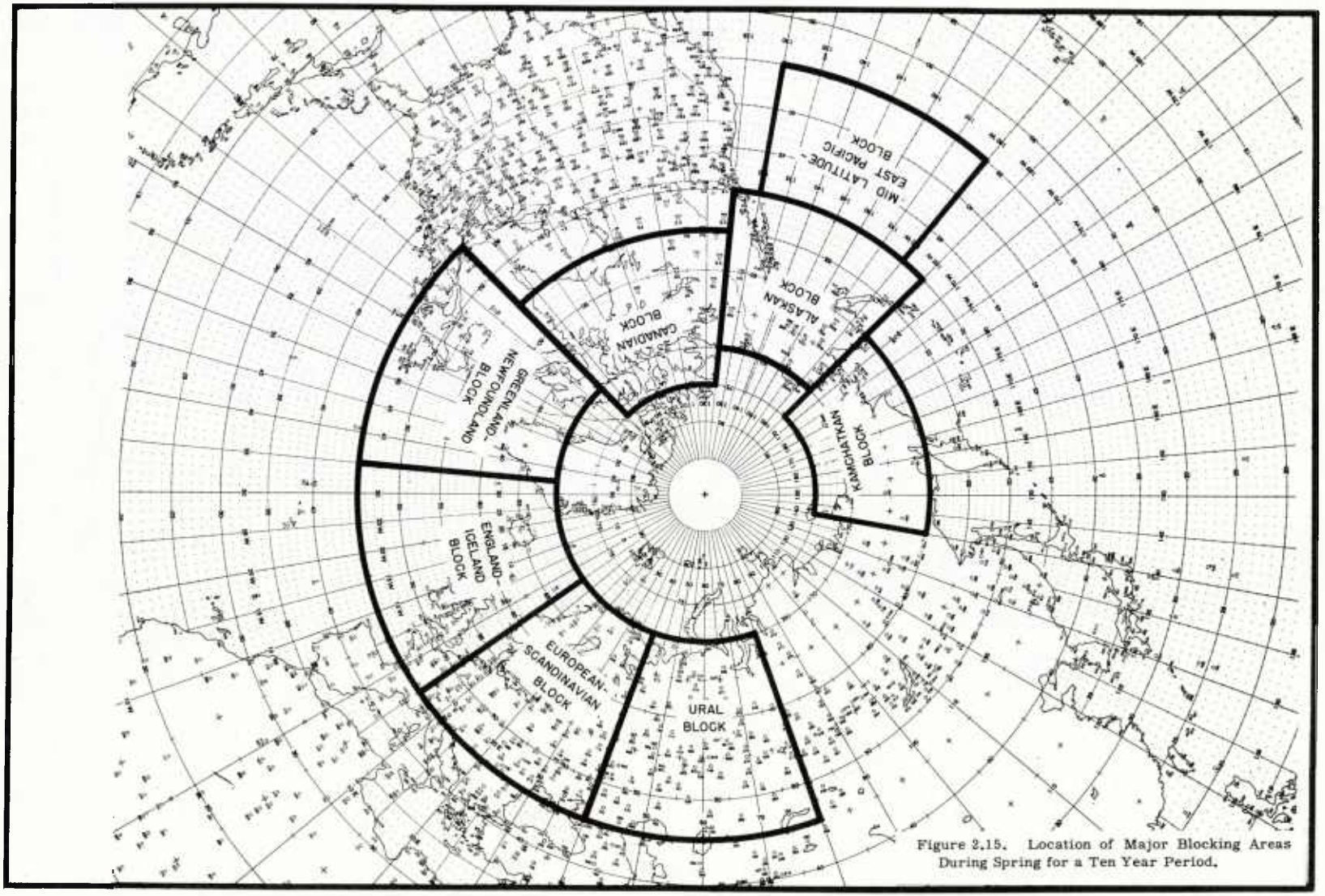

Figure 2.15. Location of Major Blocking Areas During Spring for a Ten Year Period.

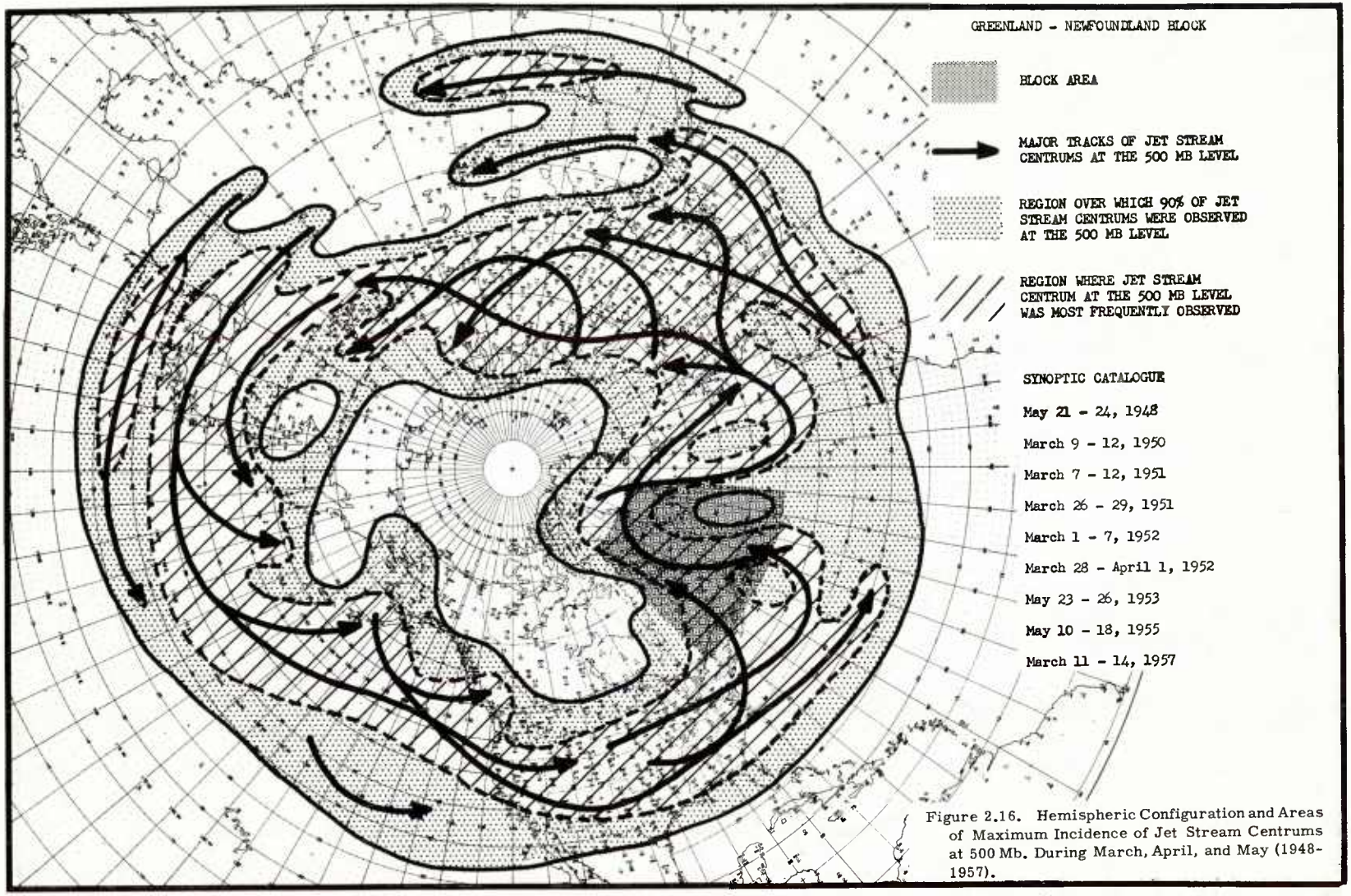

Figure 2.16. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

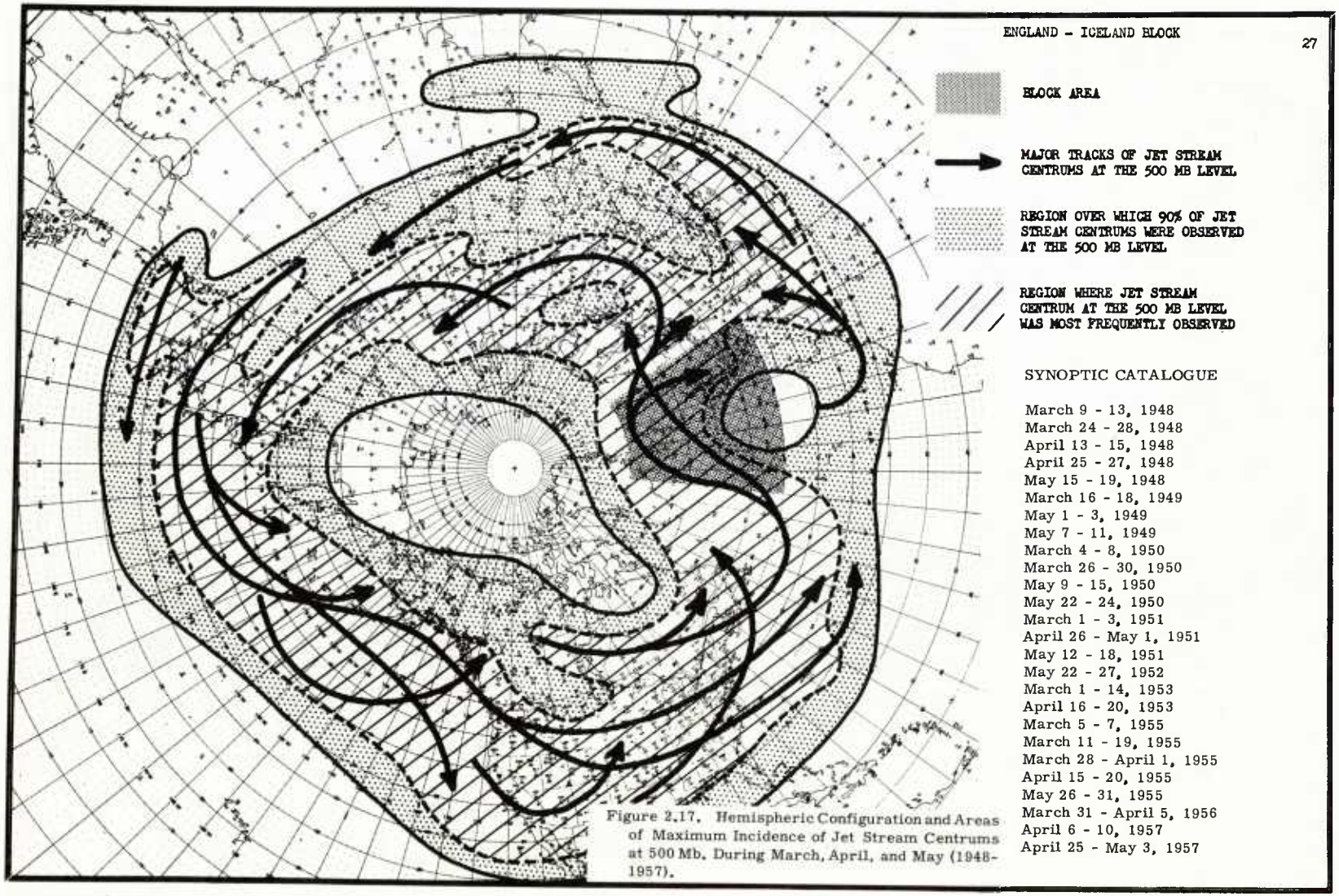

Figure 2.17. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

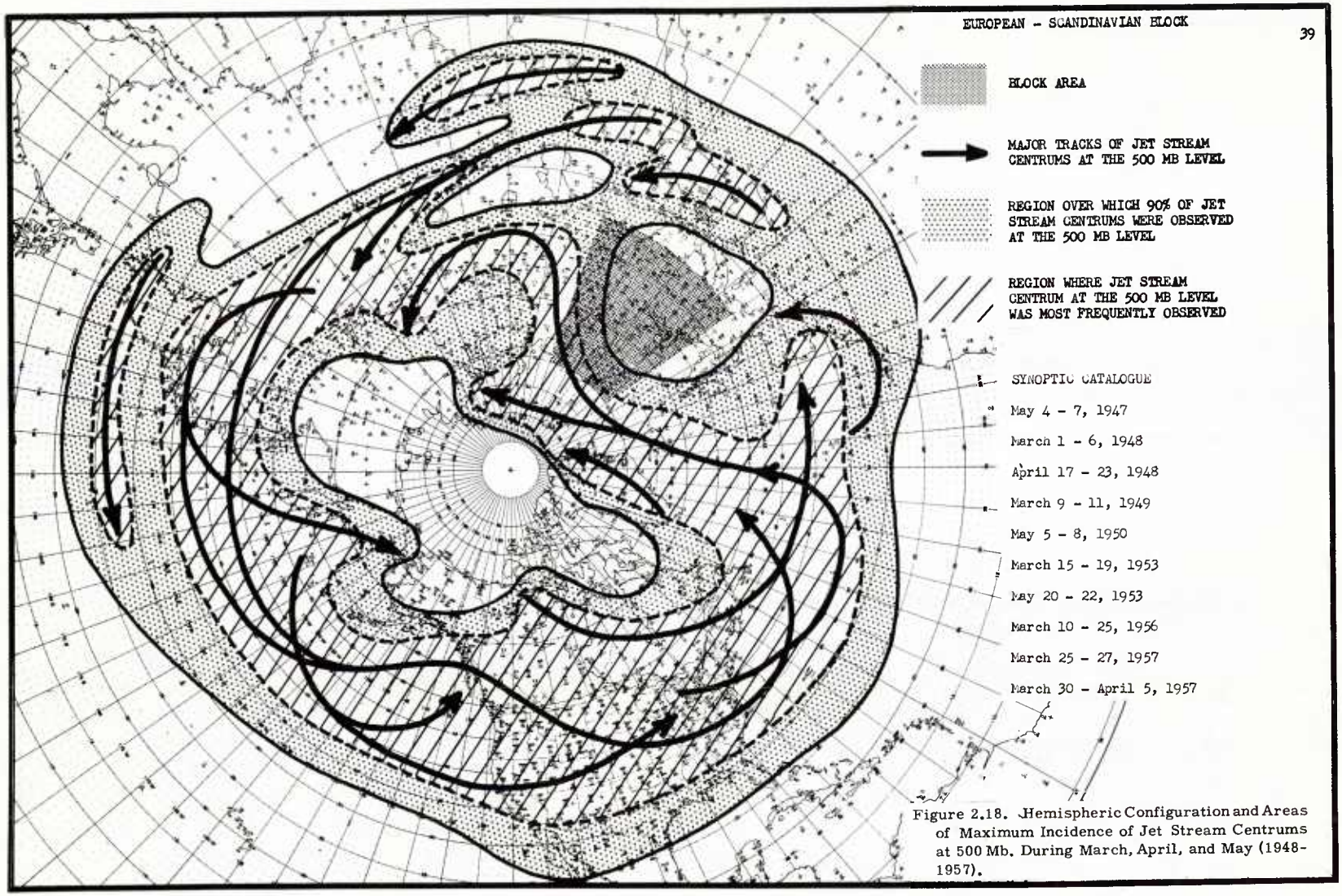

Figure 2.18. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

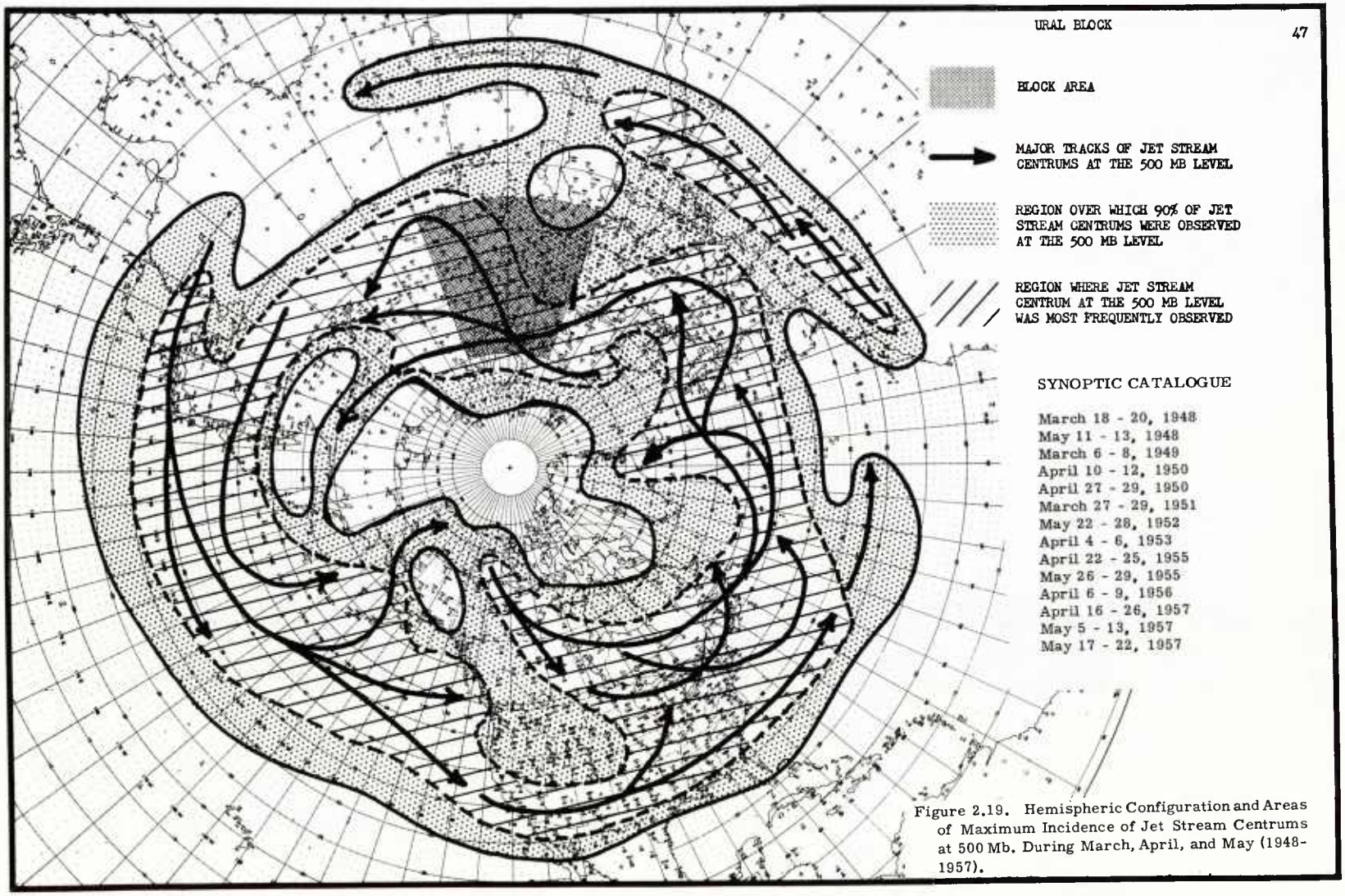

Figure 2.19. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

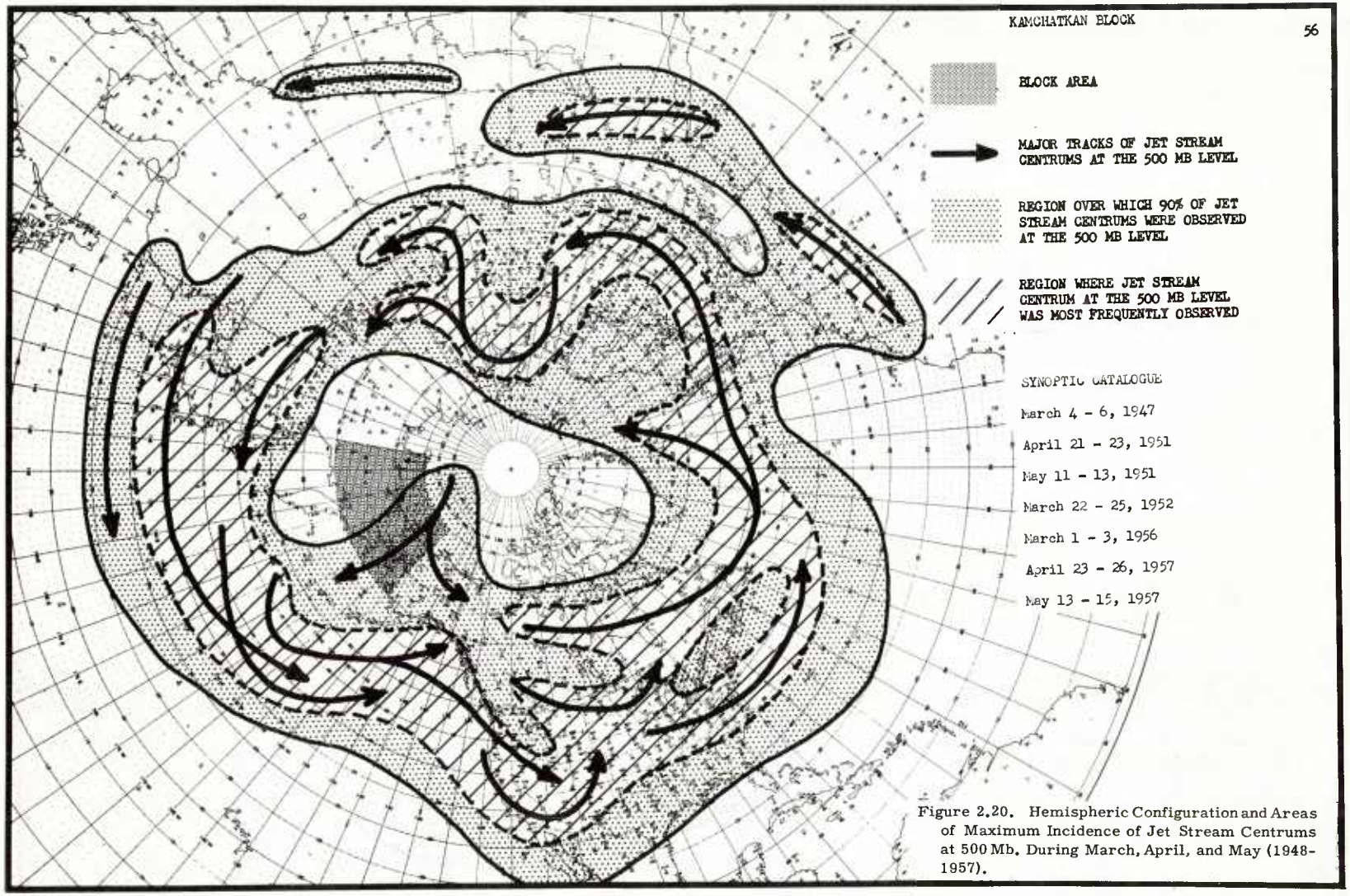

Figure 2.20. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

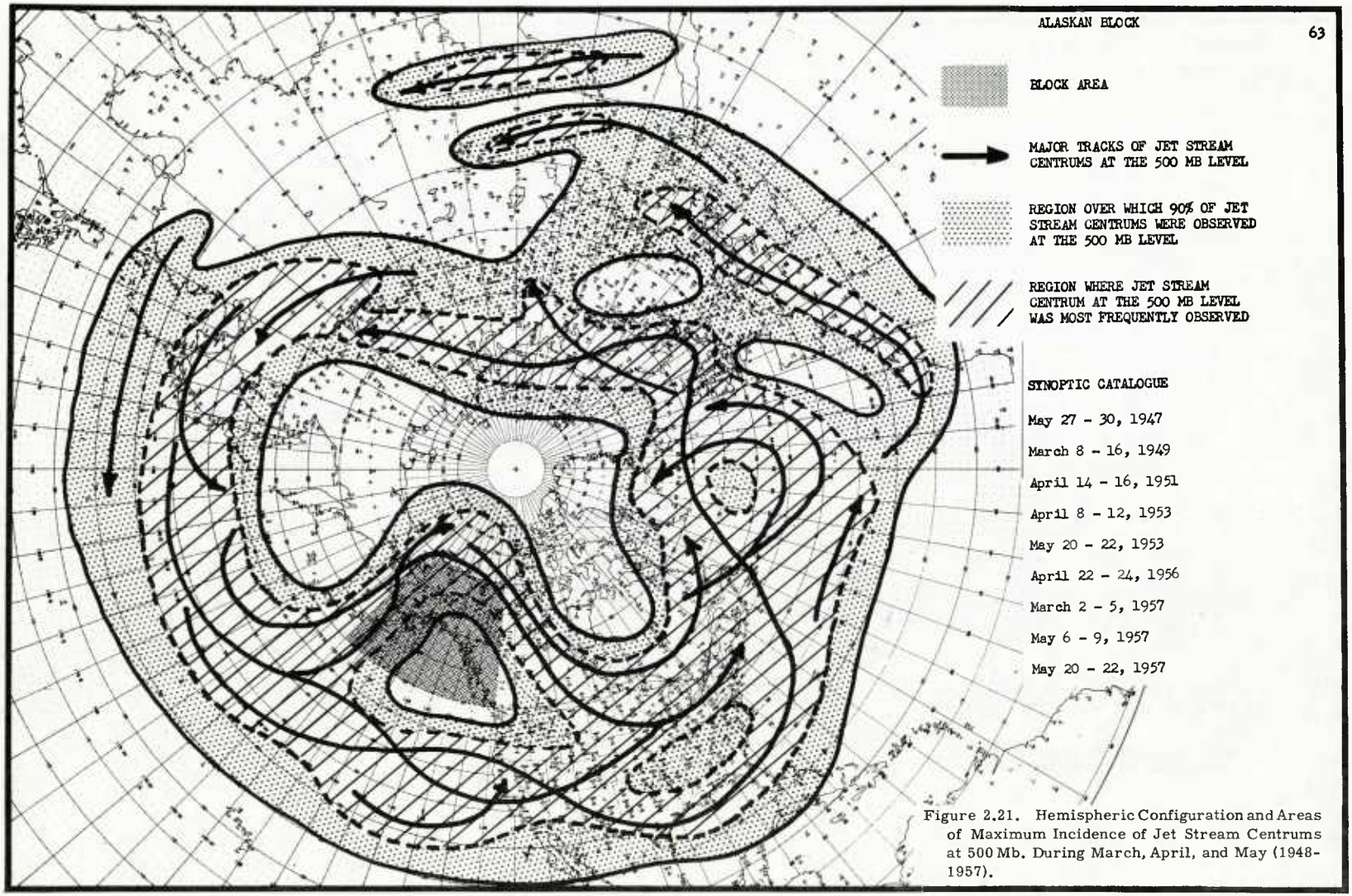

Figure 2.21. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

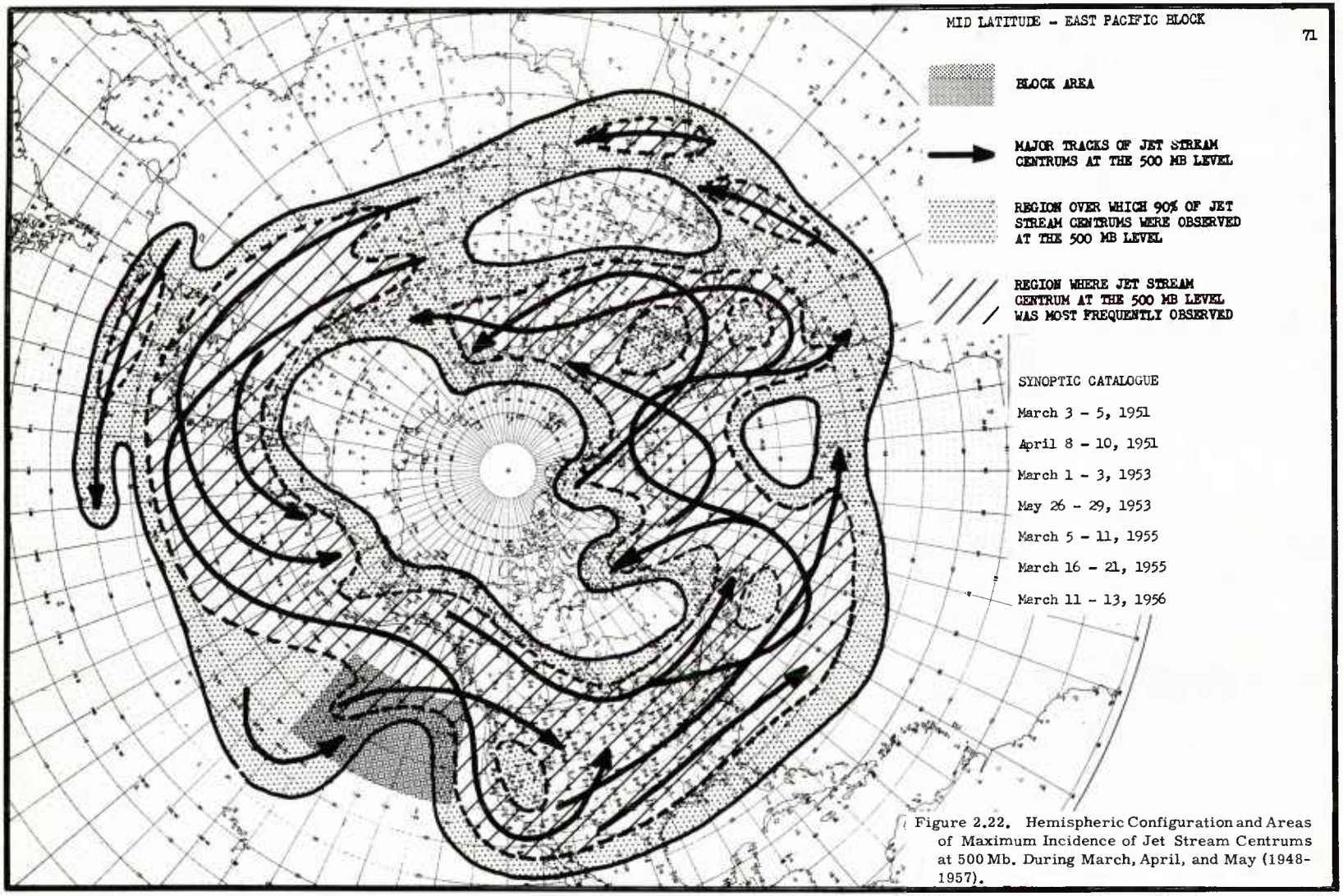

Figure 2.22. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

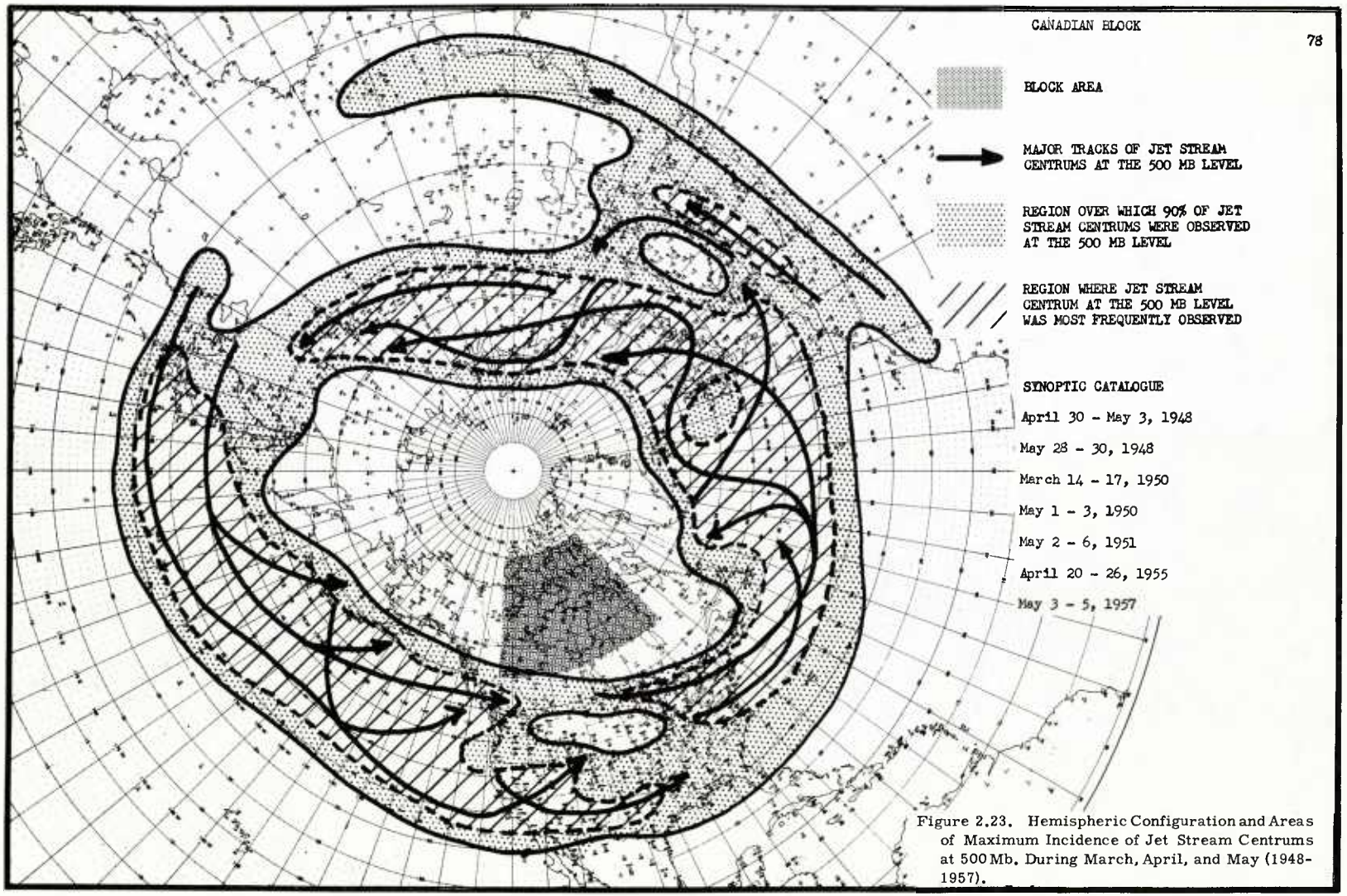

Figure 2.23. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During March, April, and May (1948-1957).

2.4 Summer

2.4.1 Greenland - Iceland Block

(a) Location: 55°N-75°N; 55°W-15°W

As the name implies, the block area lies over the southern half of Greenland and extends from the Davis Straits to the eastern periphery of Iceland (fig. 2.25).

(b) Regional Description

(1) North America

In the western portion, jet streams may be observed from lower California to the Canadian Arctic. The areas of major incidence, however, are in the Northwest Territories and western United States. Three characteristic track configurations are evident: a pronounced meridional pattern in association with high cells in Alaska, zonal orientations through central Canada, and configurations characteristic of a well developed trough in western United States. Anticyclonically curved tracks of small amplitude are apparent in the central United States. In the eastern half of North America the incidence of jet streams are confined to the area south of Hudson Bay and the track configurations reflect the presence of a well developed cyclonic vortex upstream of the block area.

(2) Atlantic and Europe

In the western Atlantic, the major incidence of jet streams are found south of the block. Jet streams do occur north of the block but the incidence is materially less. Note, however (fig. 2.25), that the major meridional incidence in close proximity to the block occurs only on the downstream side. In the eastern Atlantic and in Europe jet stream incidence is well marked. The multiple cyclonic track configurations illustrate the variability of the positions of the troughs downstream of the block.

(3) Russia and Siberia

Jet stream incidence is confined to the western portion of

Russia in latitudes north of the 50th parallel. While no particular concentration of frequency is noted, the characteristic track configurations are typically those that appear along the base and eastern periphery of troughs. The total absence of jet streams in Siberia may be due, in part, to an insufficiency of data.

(4) Japan and the Pacific

Jet streams often become reestablished in the Pacific and may be observed over an increasing span of latitudes from the western Pacific to the eastern Pacific. The areas of major concentration, however, are found in the middle latitudes. Zonal configurations are evident in Japan with trough development indicated in the central Pacific. In the eastern Pacific the tracks separate, indicating extensive zonal flow across the Pacific or, with ridging in Alaska, pronounced northward deflection into relatively high latitudes.

2.4.2 England - North Sea Block

(a) Location: 50°N-75°N; 15°W-15°E

The block area lies over England, the North Sea and a portion of the Scandinavian countries (fig. 2.26). It extends northward from England to the Arctic Circle.

(b) Regional Description

(1) North America

Jet streams in this sector are observed over an extremely wide range of latitude except for a small section of western Canada. The areas of greatest frequency are found across the northern portion of the United States and through central Canada. In the former area the characteristic configuration shows both a zonal and trough pattern in western United States becoming distinctly zonal in the eastern portion. In central Canada the configuration is decidedly meridional and is indicative of the frequent occurrence of a pronounced ridge-trough system in Canada during this type of blocking regime.

(2) Atlantic and Europe

The distribution of jet stream incidence reflects a marked frequency of well-developed cyclonic vortices upstream of the block and, consequently, jet streams undergo a marked deformation in this area. Separation is noted in the eastern Atlantic with jet streams appearing both over and under the block area with the former being the more common. In Europe the actual path is dependent on the location and amplitude of the block, but, in any case, it reveals the presence of the downstream trough.

(3) Russia and Siberia

Jet stream incidence in western and central Russia is high because of the blocking pattern upstream. The configurations are indicative of a well-developed trough, although its location may vary. Most of the jet streams are confined to latitudes above 50°N. In eastern Russia and Siberia the incidence of jet streams is small.

(4) Japan and the Pacific

Jet streams occur over a wide range of latitudes in this area. The greatest frequency is found in the eastern Pacific though the degree of concentration is not great. In general, jet stream configurations reflect the presence of a trough in the western Pacific and a ridge in the eastern Pacific. Large variability in trough and ridge locations results in the appearance of jet streams over a wide span of latitudes.

2.4.3 Scandinavian - Russian Block

(a) Location: 50°N-75°N; 15°E-50°E

This block area lies over Finland and European Russia and extends from Europe to the vicinity of the Ural Mountains (fig. 2.27).

(b) Regional Description

(1) North America

In northwestern Canada and the southern United States the incidence of jet stream centrums is at a minimum. In general, the track configurations indicate troughing along each coast. The

track configurations in the Canadian Arctic reflect the presence of low pressure areas in the North Polar region.

(2) Atlantic and Europe

Cold air outbreaks over Greenland deflect jet stream occurrences to the south of this area. No occurrences were found over Greenland itself. Jet stream incidence across the Atlantic is great between latitudes 40°N and 60°N, and cyclonic track deformations predominate. Most of the jet stream centrums undergo a pronounced cyclonic deformation in this area and then are thrust to the north of the block. A splitting of the westerlies may occur upstream of the block but as a rule few jet stream centrums were observed south of the block. Jet streams are frequent in the Mediterranean area.

(3) Russia and Siberia

This sector lies immediately downstream of the block area and the distribution of incidence and track configurations reflect the variability in location and amplitude of the block. Two distinct variations in the amplitude of the jet stream tracks are noted in the area of the downstream trough. Jet stream patterns in Siberia, in general, reflect the recurving from the base of the trough with some variability of the centrums in position tending to occur only at rather high latitudes. Lack of data perhaps accounts for the lack of jet stream incidence in this area.

(4) Japan and the Pacific

Jet stream centrums in significant numbers are observed along the rim of the Arctic and again in the middle latitudes across the Pacific. While jet streams are frequent they are subject to a great degree of variability in location, particularly in the eastern Pacific. Many track configurations exist - both zonal and cyclonic deformations are present with the latter the usual condition in the Arctic. There are no preferential pressure patterns in the Pacific though trough configurations are most often experienced in the central or eastern Pacific. Extensive zonal flow is not uncommon, however.

2.4.4 Ural Block

(a) Location: 50°N-75°N; 50°E-90°E

This block area lies over that part of the Soviet Union that extends eastward from the Ural Mountains and southward from the Kara Sea (fig. 2.28).

(b) Regional Description

(1) North America

Jet streams are observed in two distinct locations - one over the Canadian Arctic and the other over northern United States and southern Canada. The incidence of jet streams in the Canadian Arctic is confined to the area upstream of Baffin Bay while the more southerly regime extends in a ridge-trough configuration from the Pacific West Coast eastward into the Atlantic, though subject to considerable latitudinal variation. Troughing appears dominant over the East Coast.

(2) Atlantic and Europe

The centrum configurations are largely zonal west of England. At this point the configurations most frequently delineate a trough development over Europe upstream of the block area. On the other hand cyclonic configurations are also observed around a low near Greenland with characteristic tracks continuing to latitudes north of the Scandinavian countries. The troughing over Europe is the most characteristic pattern, however.

(3) Russia and Siberia

Jet streams, in general, are thrust over the block into very high latitudes though, on occasion, they are found to the south of the block. Downstream of the block the tracks usually undergo a pronounced cyclonic deformation. Interestingly enough, jet streams are observed more often upstream of the block than downstream though this may be due to the distribution of data. Siberia, except for the Arctic region, is free of jet stream incidence.

(4) Japan and the Pacific

Track configurations in the Pacific may reflect both zonal and meridional orientations. Well-developed troughs may occur from Japan to the eastern Pacific. Jet streams were not observed in significant numbers in southern Alaska but were present more often in the Canadian Arctic area. Jet streams were observed in two main locations in the longitude of Japan - one north of the 70th parallel and the other between 35°N and 40°N latitude. Over the Pacific most of the occurrences were found north of the 40th parallel and east of 160°E longitude.

2.4.5 Central Siberian Block

(a) Location: 55°N-75°N; 90°E-140°E

This block area is centered over central Siberia and extends northward from Lake Baikal to the Arctic Circle (fig. 2.29).

(b) Regional Description

(1) North America

Jet streams are observed with greatest frequencies through the northern United States and central Canada. Western Canada is characterized by a near absence of jet stream occurrence. In Canada, the track configurations near the Arctic Circle are decidedly cyclonic with meridional patterns in the central and eastern portion of Canada indicative of a ridge-trough pressure pattern. The ridge is centered in western Canada and the trough is usually located near the Davis Straits area. Considerable variation both in longitude and amplitude may occur.

(2) Atlantic and Europe

A variety of configurations are apparent in the Atlantic. The main trough areas occur off the East Coast of the United States and immediately off France. The areas of Greenland and the North Sea are largely free of jet stream incidence. In Europe the track configurations generally curve northeastward into Russia. During some synoptic situations a jet stream track may penetrate southeastward into the Mediterranean, though not frequently.

(3) Russia and Siberia

Jet streams, in general, are confined to the European and central Russian areas north of the 50th parallel. They are observed, however, as far north as the 85th parallel. The track configurations indicate a well-developed trough immediately upstream of the block area. The tracks show decided anticyclonic curvature over the block area; jet streams by and large are not observed south of the block.

(4) Japan and the Pacific

Jet streams in the Arctic area are a continuance of the jet stream field over the Siberian block. A pronounced trough configuration is apparent in the Beaufort Sea. In the middle latitudes jet streams are found south of the block area beginning near Korea and extend across the Pacific. The area of principal frequency varies from 40°N - 45°N near Japan to 50°N - 55°N in the Gulf of Alaska. The track configurations, as a rule, do not undergo great displacement although a trough pattern in the western Pacific and a ridge pattern in the eastern Pacific are commonly observed. A trough configuration is apparent off the West Coast of the United States.

2.4.6 Manchurian - Okhotsk Sea Block

(a) Location: 40°N-55°N; 120°E-160°E

This block area extends from Manchuria to the longitude of the Kamchatka Peninsula (fig. 2.30). It lies immediately north of Korea and Japan extending to the Sea of Okhotsk.

(b) Regional Description

(1) North America

Two distinct areas of jet stream incidence are noted, one along the Canadian - U. S. border and a second near the Canadian Arctic. The track configurations in the Arctic area are cyclonic and reflect the appearance of troughs along the Arctic rim. Track configurations along the Canadian border indicate the progression of troughs across Canada. The deepest troughs occur in eastern Canada with pronounced cyclonic deformation in the track configuration. Jet stream incidence is at a minimum over western

Canada and the southern United States.

(2) Atlantic and Europe

This region is characterized by a concentration of jet stream incidence between 50°N and 60°N latitudes. Greenland itself is largely free of jet stream occurrences during this blocking regime. Two major track configurations are evident. One reflects trough conditions along the western Atlantic and England with zonal flow or weak ridging in the central Atlantic. The other indicates that with strong trough conditions over Greenland a jet stream track may be evident south of Greenland and/or Iceland. In Europe the centrums are deflected northward to very high latitudes. Jet streams may also be observed in the Mediterranean area.

(3) Russia and Siberia

Nearly all the jet stream occurrences are found in the relatively high latitudes (i.e., north of the 55th parallel), though the frequency is quite small. No particular tendency for concentration was noted. The centrum configurations in this area reflect the presence of troughs just west of Lake Baikal and in the Beaufort Sea. Jet streams are not evident in Manchuria due to lack of adequate data.

(4) Japan and the Pacific

In the Arctic the jet streams exhibit the characteristic configuration indicative of a trough in the vicinity of the Beaufort Sea. Jet streams are observed south of the block area although not in great numbers. In the central and eastern portion, however, jet streams are more numerous and tend to concentrate to some degree. Ridging is quite common in the central Pacific with trough configurations in the Gulf of Alaska and along the West Coast of the United States. The configuration in the western Pacific indicates the presence of jet streams around small low centers south or southeast of the block.

2.4.7 Kamchatkan Block

(a) Location: 55°N-75°N; 140°E-170°E

This block area lies over eastern Siberia terminating at the tip of Alaska (fig. 2.31). It extends northward from the central portion of the Kamchatka Peninsula to the Arctic Circle.

(b) Regional Description

(1) North America

A well developed trough is usually found in the Pacific Northwest and, with the exception of some occurrences near the Canadian Arctic, jet streams are centered primarily south of the Canadian border. In general the configurations across the United States are primarily zonal. A secondary zone of significant incidence is located near Hudson Bay reflecting the eastward displacement of the Hudson Bay low.

(2) Atlantic and Europe

While the distribution of jet stream incidence and track configurations in the western Atlantic largely reflect zonal conditions, a pronounced trough-ridge or second block pattern is evident in the eastern Atlantic. This pattern may undergo considerable variation but, in general, the trough is located south of Greenland or Iceland with the ridge centered near England. On occasion, this ridge may be replaced by a well developed trough with consequent cyclonic jet stream configurations through this area. Jet streams in Europe are normally meridional since this area lies downstream of the ridge.

(3) Russia and Siberia

Jet streams in European Russia are a continuation of the jet stream field downstream of a ridge or block over England though confined to latitudes north of the 50th parallel. Cyclonic track configurations in central Russia reflect the presence of Arctic low pressure areas. In Siberia the area of jet stream incidence is markedly limited to the Arctic regions. No jet streams were observed in eastern Russia probably due to lack of adequate data.

(4) Japan and the Pacific

Jet streams are observed in greater number to the south of

the block area in the western Pacific than to the north. Characteristic trough configurations are observed in the high latitudes between Siberia and Alaska, as well as to the southeast of Kamchatka. Both zonal and meridional configurations of the jet stream are apparent in the eastern Pacific with ridging being the principal synoptic pattern.

2.4.8 Alaskan Block

(a) Location: 55°N-75°N; 170°W-130°W

This block area lies over the entire portion of Alaska between Siberia and the Canadian Yukon and extends northward from the Aleutian Islands to the Arctic circle (fig. 2.32).

(b) Regional Description

(1) North America

Jet streams in northern Canada are generally meridional, downstream of the block, culminating in a cyclonic deformation around a trough near Baffin Bay. On some occasions jet streams may be evident around lows southeast of the block. Under these circumstances jet stream configurations in the central United States become fairly zonal.

(2) Atlantic and Europe

Cyclonic configurations predominate in the Atlantic with the major trough either along the East Coast of the United States or just west of England. In Europe there is usually an additional block which causes the jet stream centrums from the East Atlantic to be deflected northward to high latitudes. Sometimes, however, the zonal orientation of the jet stream in the East Atlantic continues directly into Europe.

(3) Russia and Siberia

When strong ridging conditions prevail in Europe the downstream trough is found in central Russia with the jet stream configurations predominantly meridional. The incidence of jet stream centrums in this area was materially less than in Europe.

In Eastern Siberia a trough or cyclonic vortex upstream of the principal block is often well developed and under these conditions jet streams are thrust to the south of Kamchatka.

(4) Japan and the Pacific

Because of the high latitude of the block a well developed trough-ridge configuration is noted in the Pacific with jet streams being thrust into very high latitudes. Upstream of the block jet streams are particularly frequent in occurrence and usually well developed. There is some tendency for jet streams to undercut the block.

2.4.9 Sub-Aleutian Block

(a) Location: 40°N-55°N; 170°W-140°W

This block area lies west of British Columbia and immediately south of the Gulf of Alaska and the Aleutian Islands (fig. 2.33).

(b) Regional Description

(1) North America

The greatest incidence of jet streams occur in the vicinity of the Canadian border. In general, a well developed trough is usually present along the West Coast; on occasions, however, the track configurations become predominantly zonal. While an occasional trough is found along the East Coast of the United States, ridges (and consequent anticyclonic jet stream configurations) are more characteristic.

(2) Atlantic and Europe

In this sector three significant configurations are observed: (1) zonal flow in the middle latitudes; (2) meridional configurations of an "omega" type occurring with blocking near Iceland. (Due to the variations in location of the blocking area the upstream and downstream troughs also vary but, in general, are found in the central Atlantic and eastern Europe, respectively.); (3) broad scale ridging with a downstream trough not apparent west of central Russia.

(3) Russia and Siberia

Jet streams may be found over a wide range of latitudes but tend to concentrate in central Russia. The track configurations are indicative of the trough conditions that usually exist near the Black Sea and central Russia. On occasion, a well developed low in the Arctic results in a meridional track configuration. In Siberia the incidence of jet streams is quite low.

(4) Japan and the Pacific

The jet stream configuration in the Pacific is characterized by a pronounced trough-ridge pattern. Although the trough near Japan oscillates (as evidenced by the two track configurations in the western Pacific) the path of the jet stream over the block area is rather fixed. No occurrences were found to the south of the block area. The trough downstream of the block is generally located along the West Coast of the United States. In addition, low pressure areas in the Beaufort Sea often results in cyclonic track configurations immediately north of the block area.

2.4.10 Central Canadian Block

(a) Location: 55°N-75°N; 90°W-130°W

This block area extends over western Canada from the Yukon to the westward portion of Hudson Bay and lies to the south of the Canadian Arctic (fig. 2.34).

(b) Regional Description

(1) North America

Jet streams are observed in significant number both over and under the block area. By and large, the majority of jet stream occurrences are located north of the 40th parallel. Those jet streams north of the block are usually well developed with a pronounced anticyclonic configuration. While jet streams are most frequently observed in northern Canada, they may also be found within the Arctic circle. Jet stream configurations south of the block area are largely zonal, though the presence of a well developed trough system along the East Coast of the United States is

quite common.

(2) Atlantic and Europe

Jet stream configurations in the western Atlantic exhibit cyclonic deformation resulting from the presence of the trough off the East Coast of the United States. In the eastern Atlantic as well as in Europe, both cyclonic and anticyclonic deformations may exist although a cyclonic deformation appears to be the more characteristic. Few jet streams are observed in the Davis Straits - Greenland area.

(3) Russia and Siberia

Jet stream incidence in Russia is confined to latitudes north of the 50th parallel with the majority of occurrences between 50°N and 70°N latitude. In general the configurations delineate the presence of a trough system in central Russia, particularly during periods of pronounced ridging north of England. In Siberia the upstream configuration is usually zonal with appearances of northwesterly jet streams near the Kuriles. The Sea of Okhotsk and the Kamchatka Peninsula are relatively free of jet stream incidence.

(4) Japan and the Pacific

Jet streams in the western Pacific are generally confined to the latitude span 35°N to 50°N and, in addition, are quite zonal in character. In the eastern Pacific, however, the configurations become influenced by the presence of the block in Canada. In this area jet streams terminate in the Gulf of Alaska or, in certain cases, undergo strong cyclonic deformation and penetrate to high latitudes north of the block.

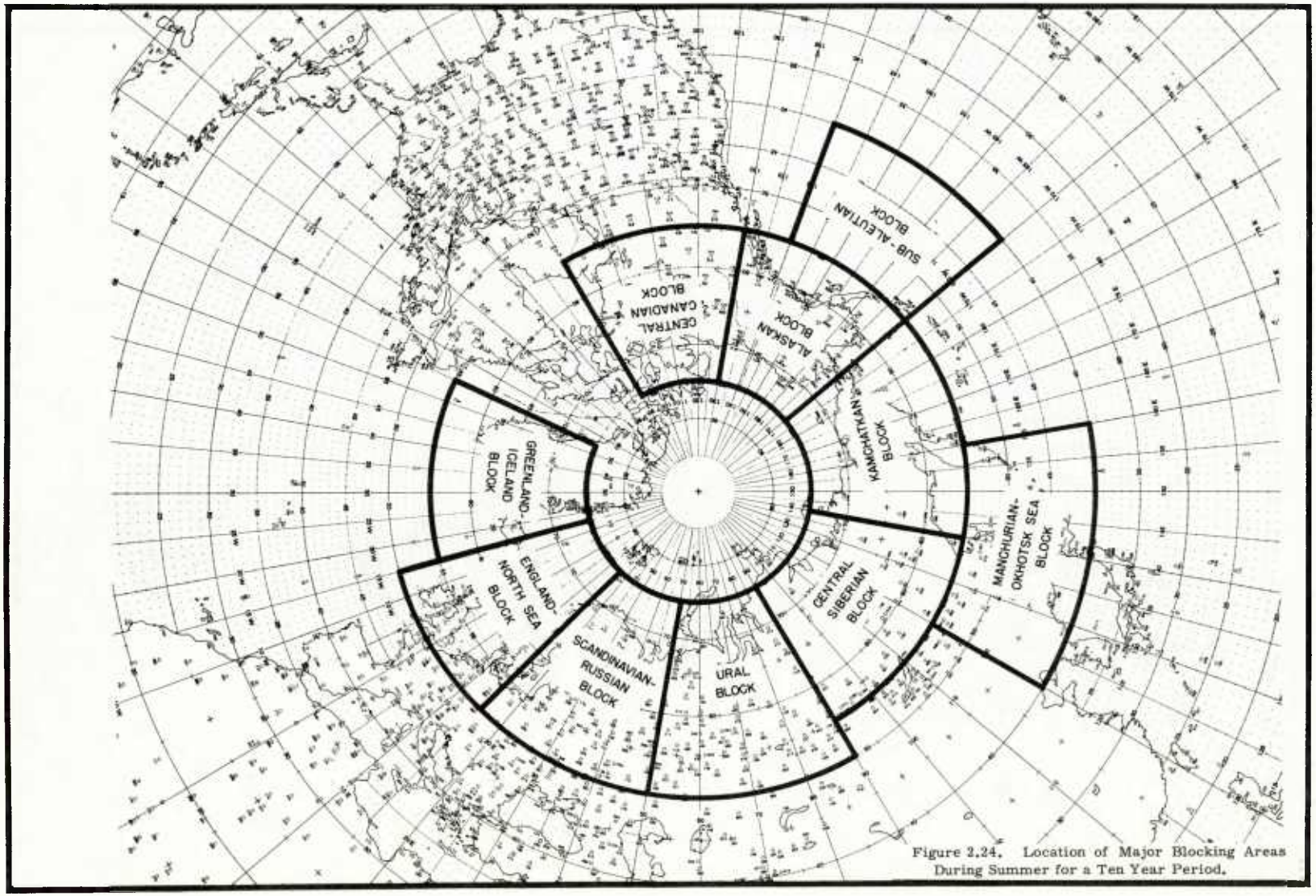

Figure 2.24. Location of Major Blocking Areas During Summer for a Ten Year Period.

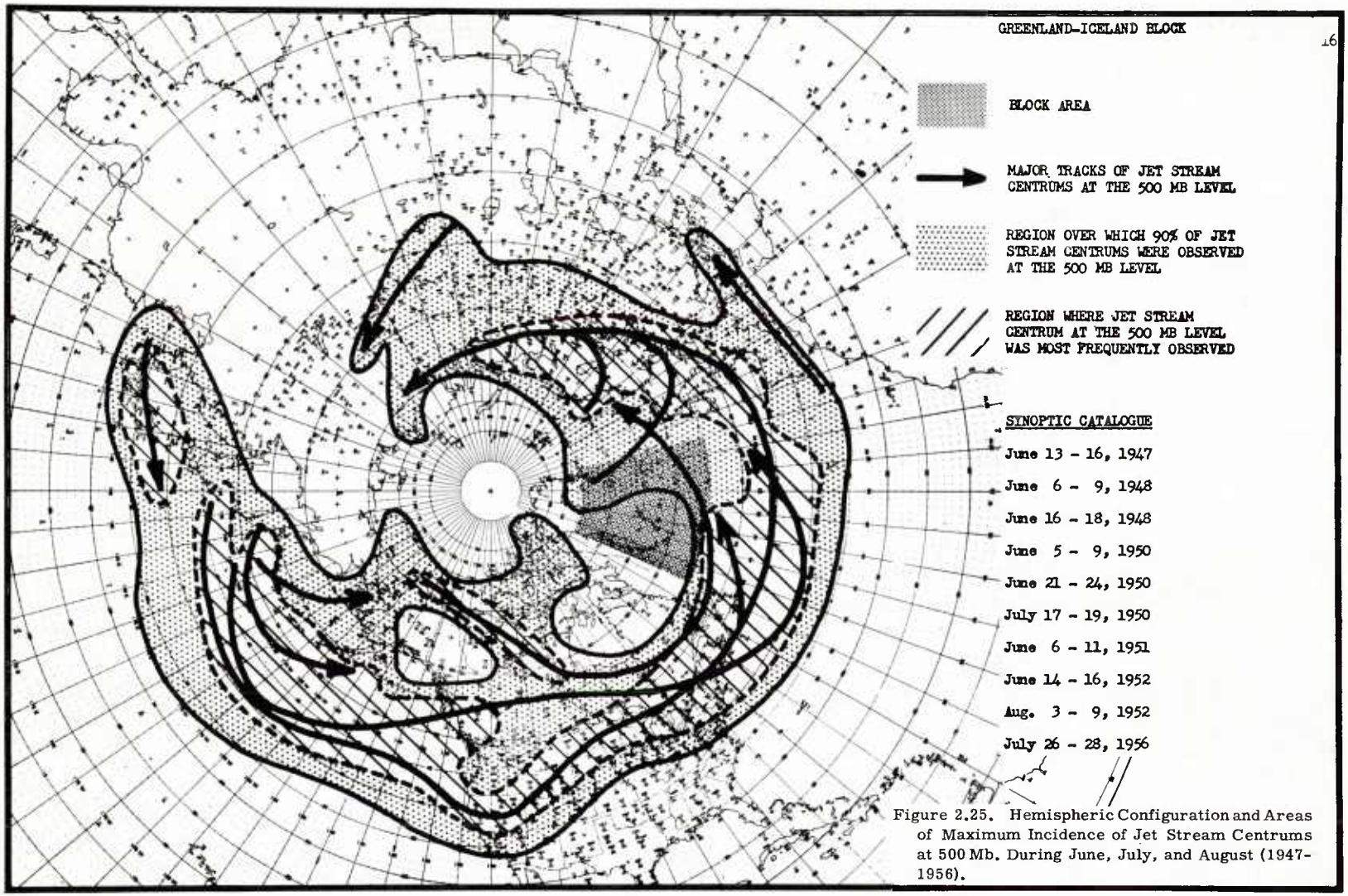

Figure 2.25. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

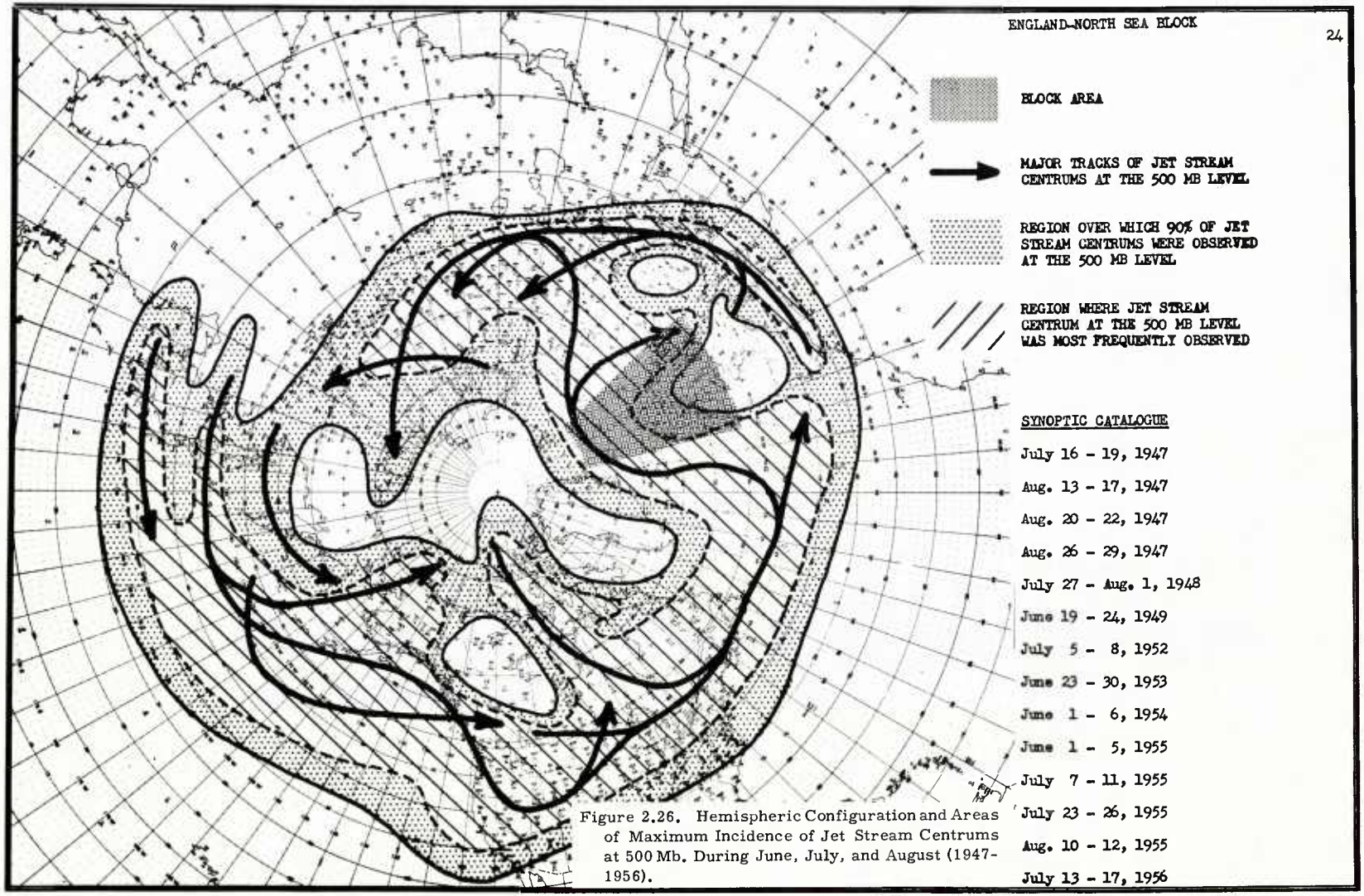

Figure 2.26. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

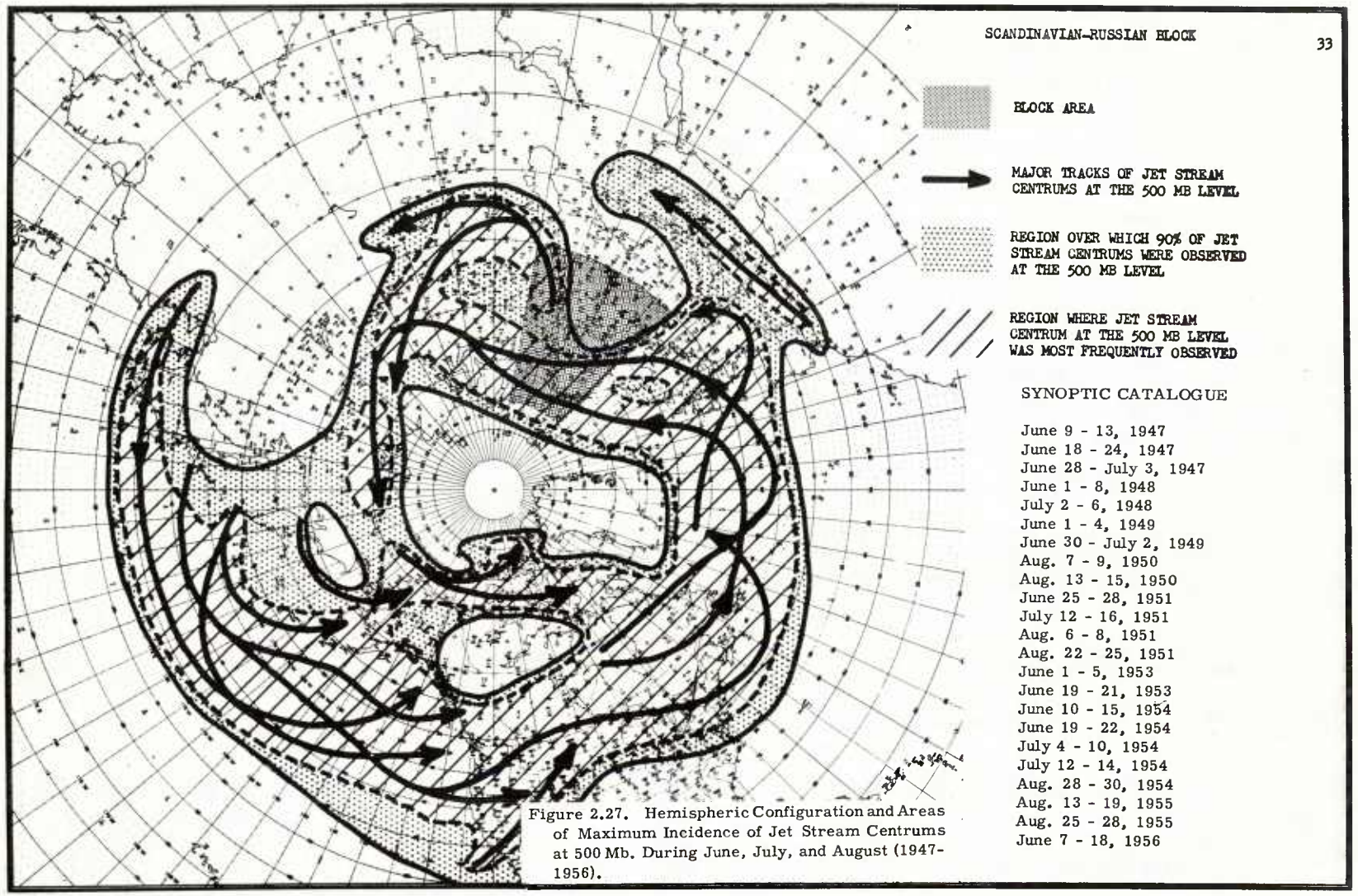

Figure 2.27. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

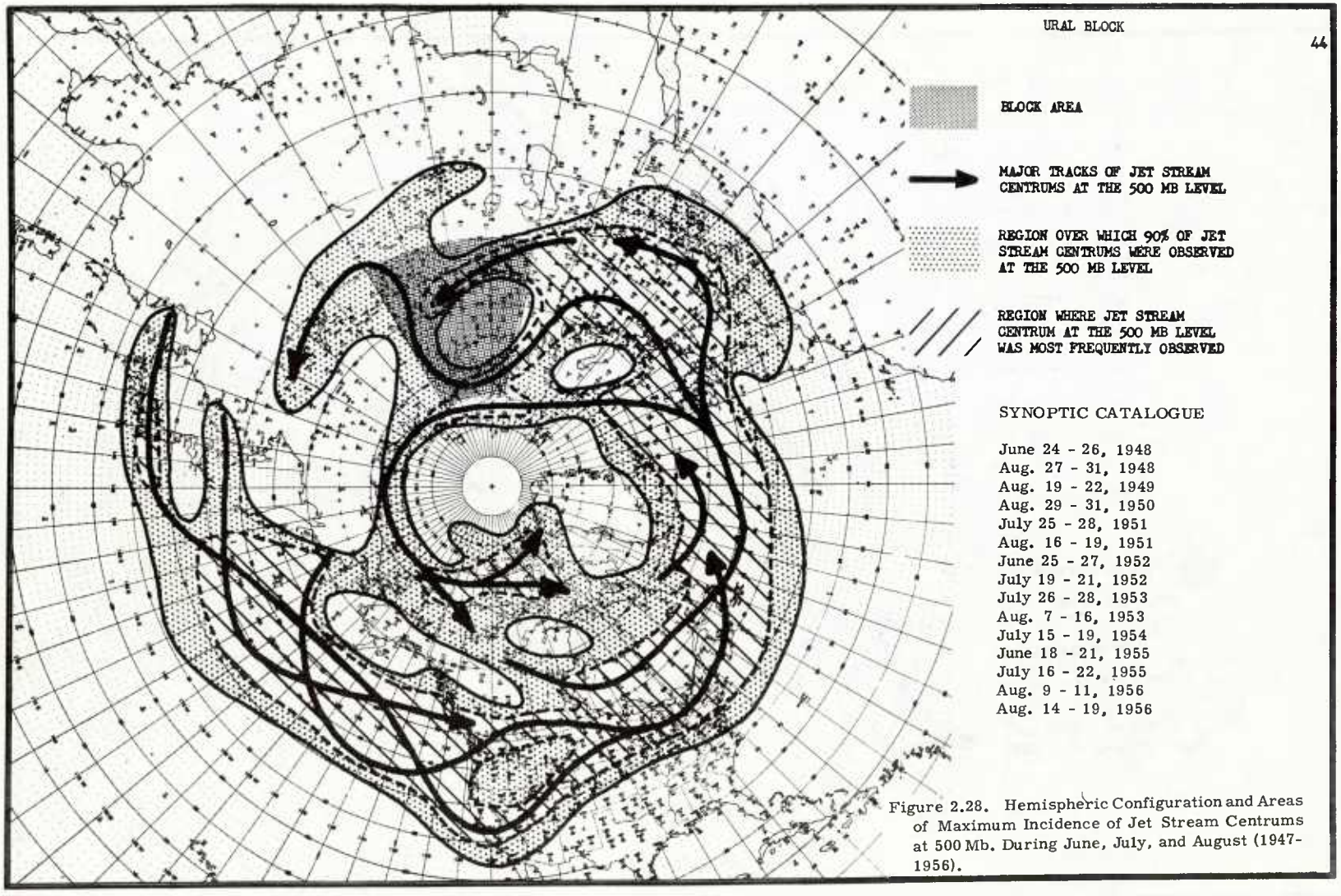

Figure 2.28. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

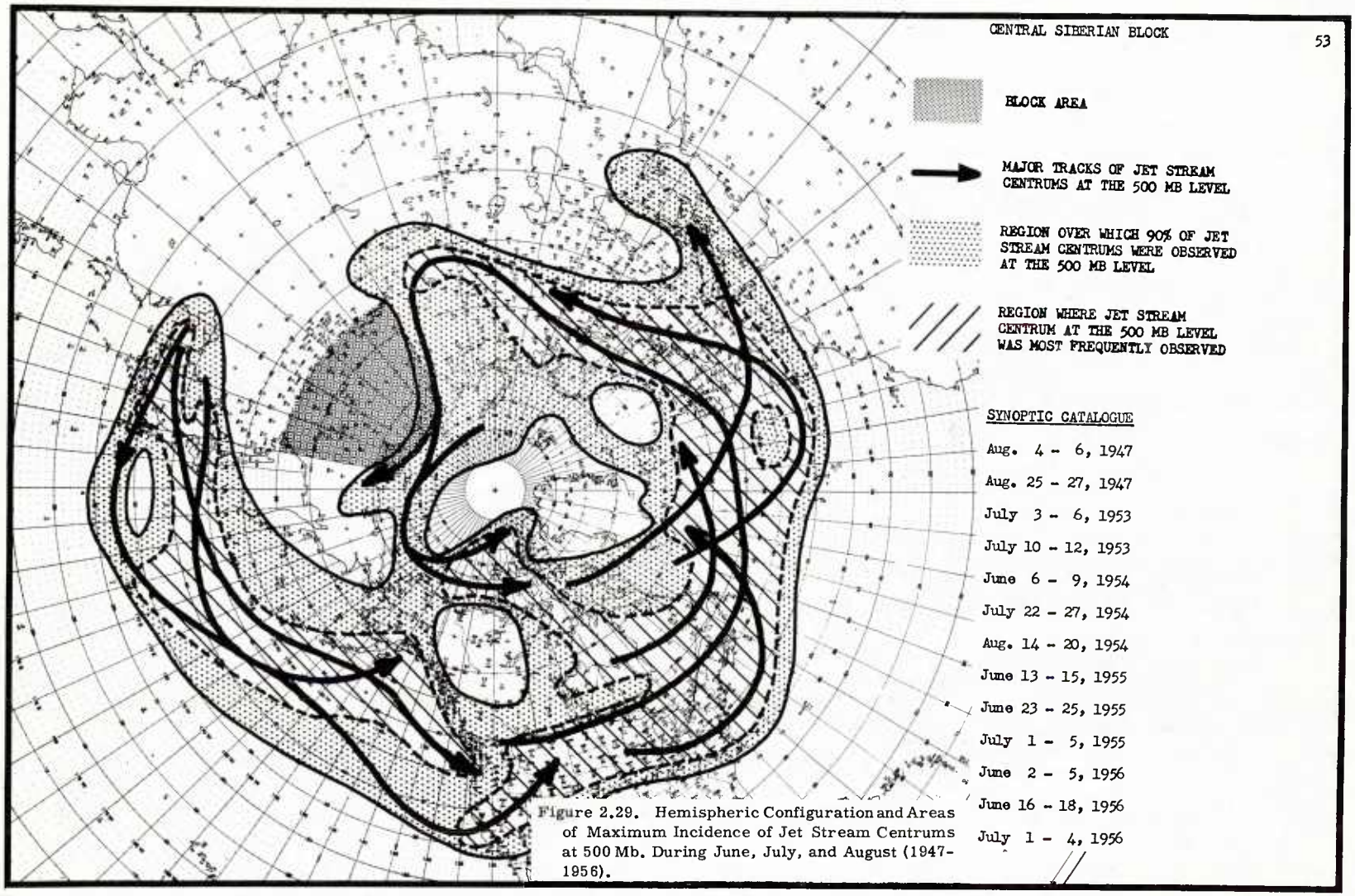

Figure 2.29. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

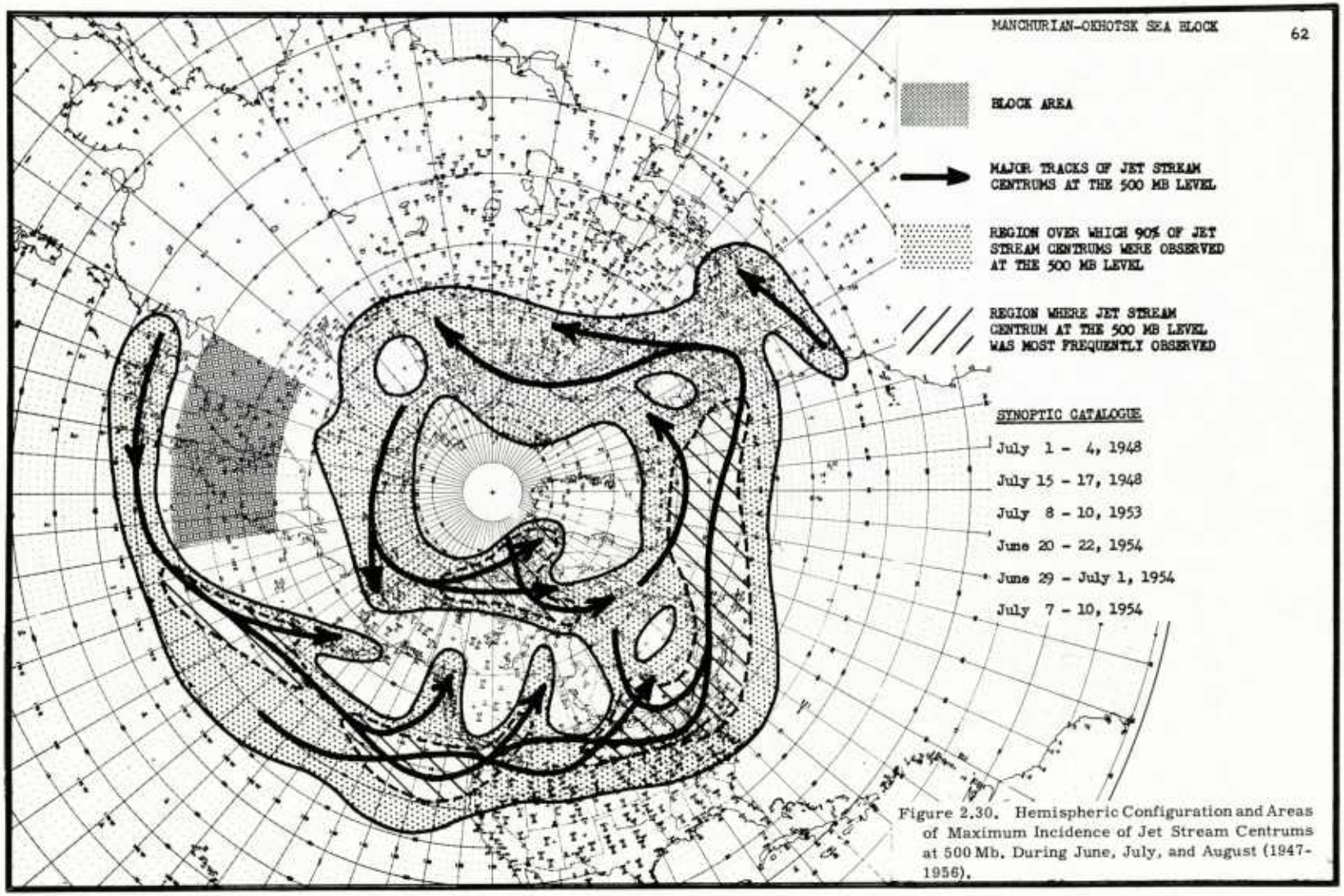

Figure 2.30. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

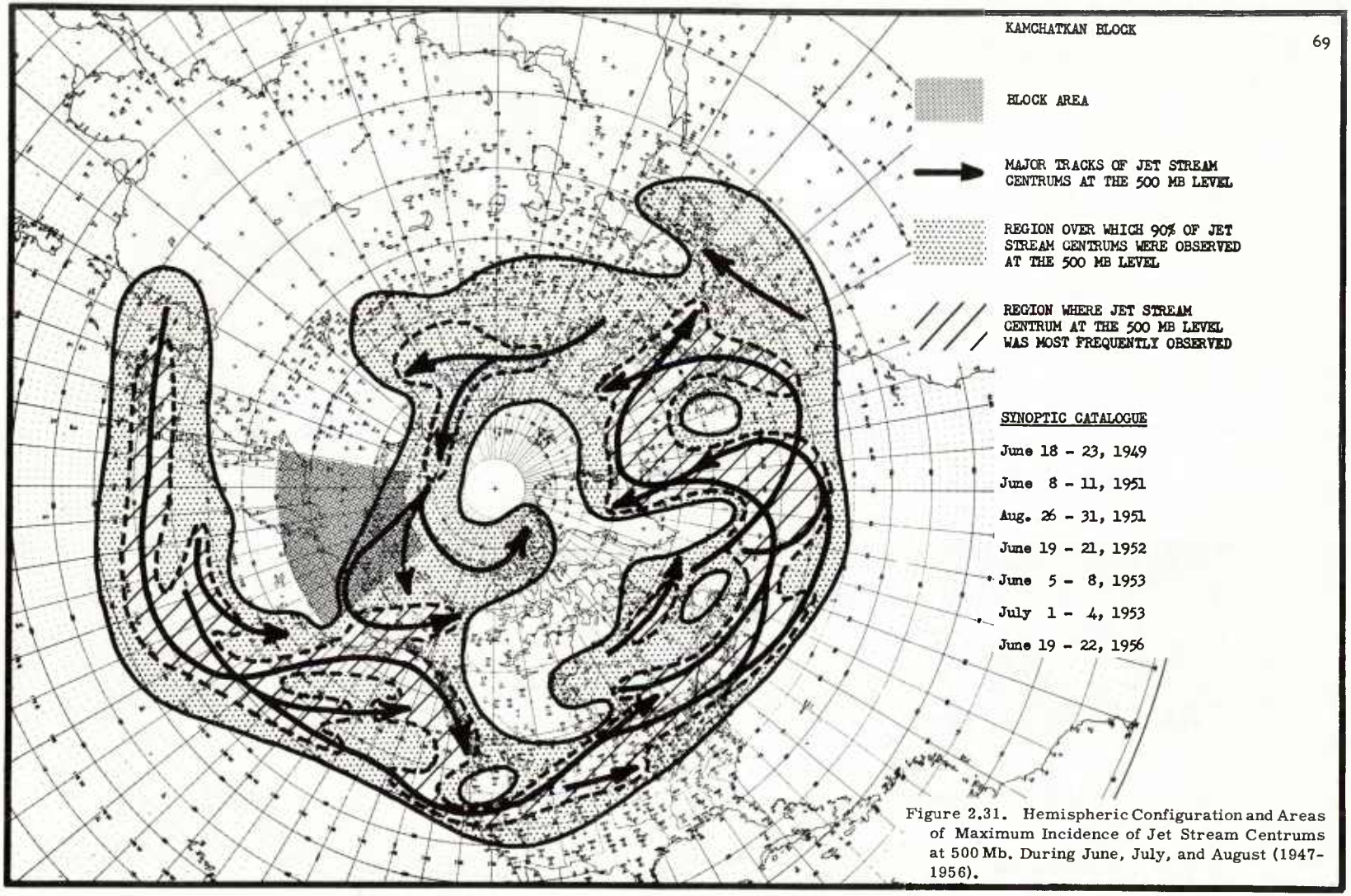

Figure 2.31. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

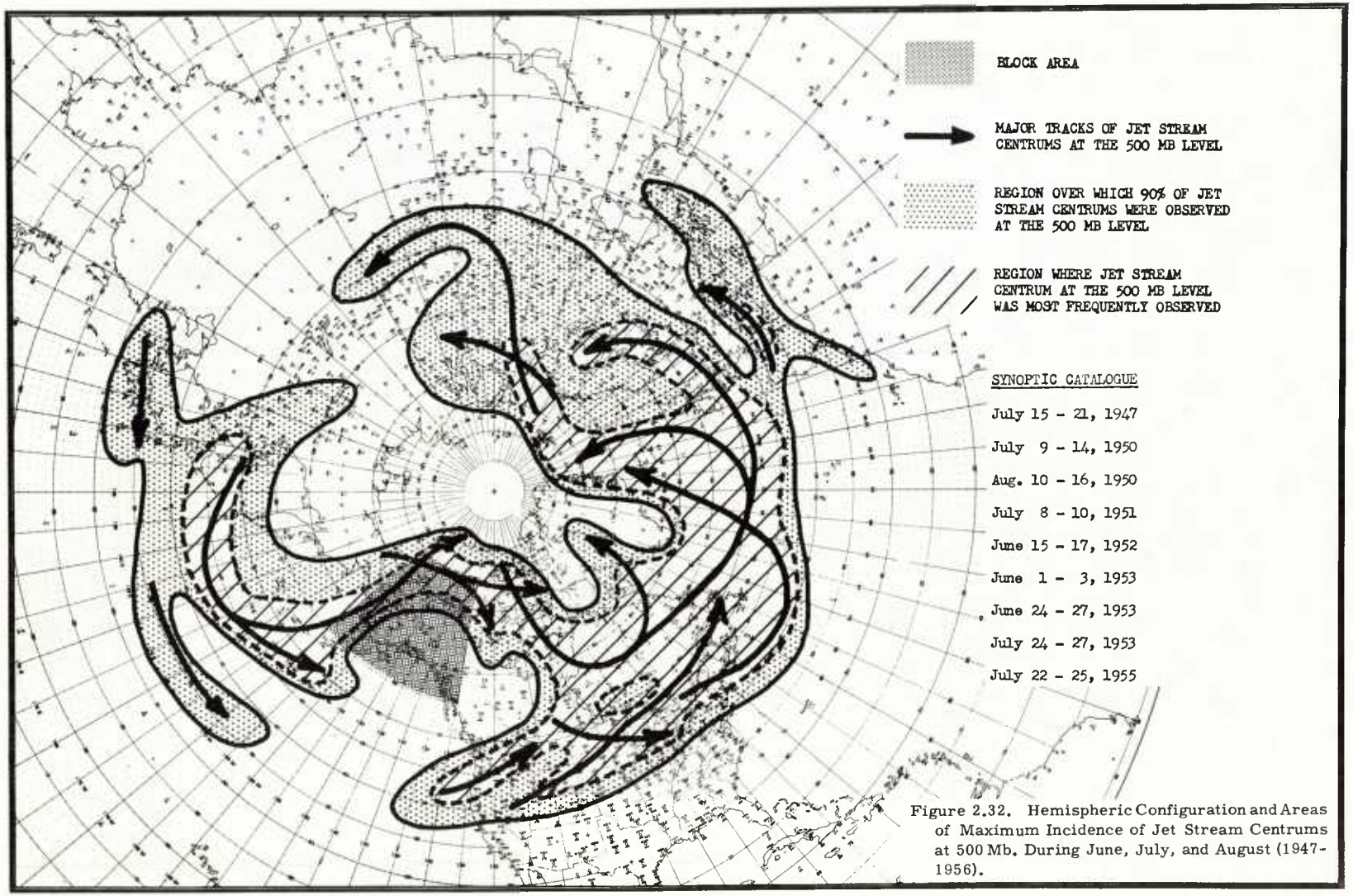

Figure 2.32. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

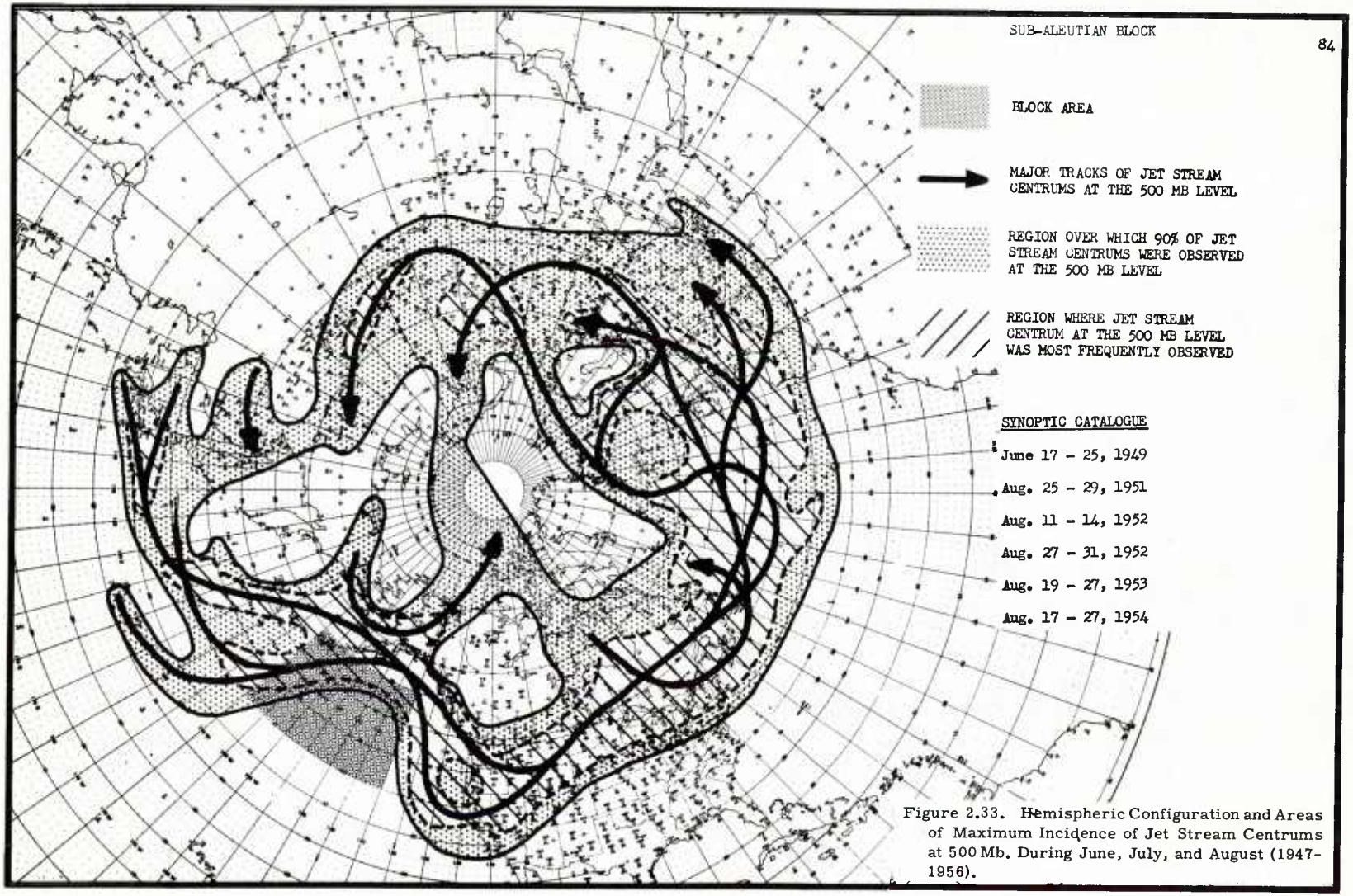

Figure 2.33. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

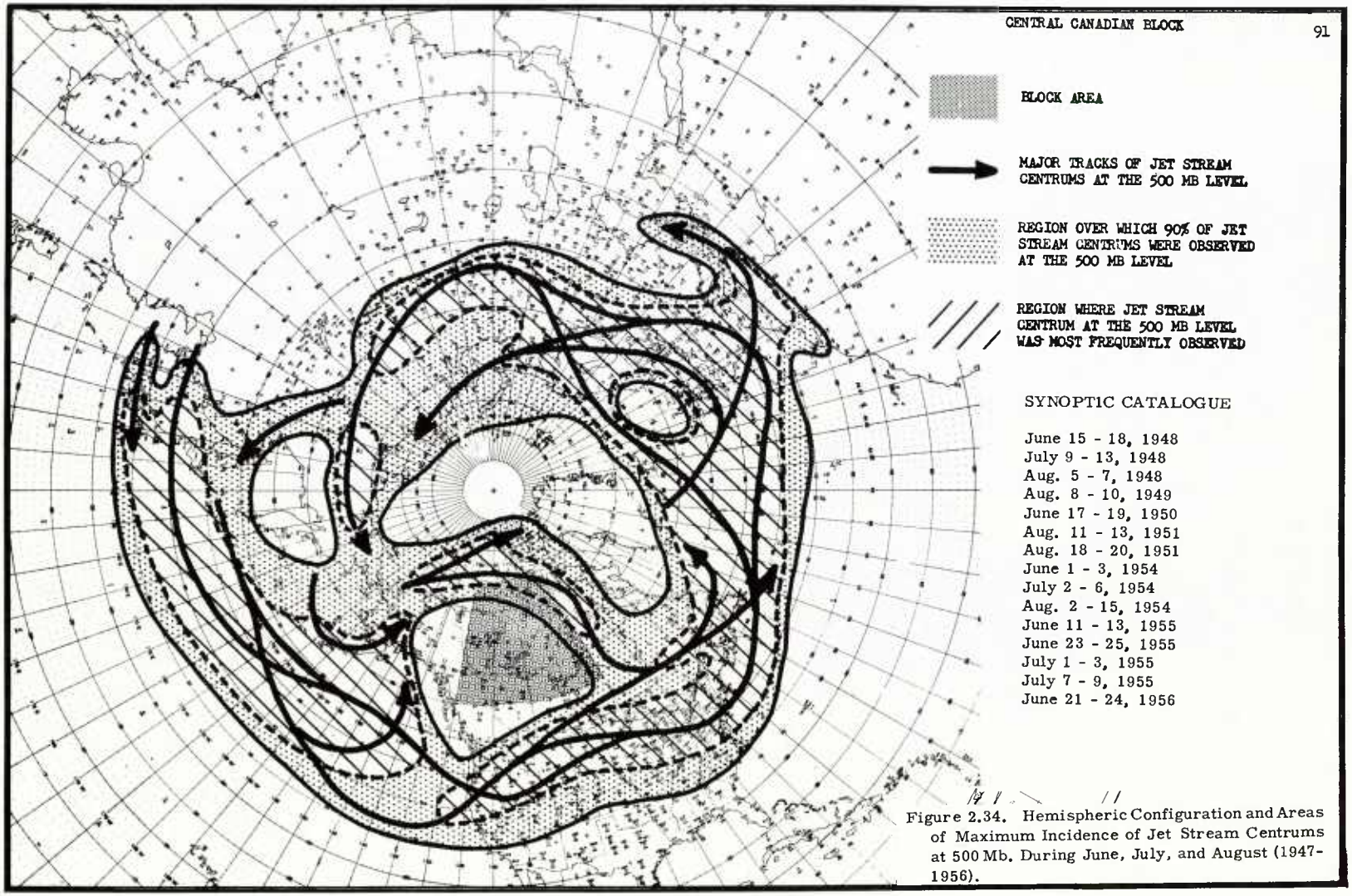

Figure 2.34. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During June, July, and August (1947-1956).

2.5 Fall

2.5.1 Greenland - Newfoundland Block

(a) Location: 50°N-70°N; 75°W-35°W

The block area extends eastward from Hudson Bay to the southeast coast of Greenland and northward from Newfoundland to Baffin Bay (fig. 2.36). It is centered over the Davis Straits region.

(b) Regional Description

(1) North America

Jet stream incidence in this region is influenced by the amplitude and location of the blocking high in the Atlantic. Pronounced troughing in the eastern United States and ridging along or just off the West Coast is the dominant pressure pattern. As a result, the majority of jet stream occurrences are found within the United States. On those occasions when ridging is located in the Gulf of Alaska a well developed trough configuration in the southwest United States, coupled with a second trough in the Great Lakes area, is characteristic. When ridging is centered on the West Coast, only the trough configuration in central United States is evident. The area from Hudson Bay to the Canadian Yukon is usually free of any appreciable jet stream incidence.

(2) Atlantic and Europe

Although blocking highs do differ considerably in longitude and latitude from one case to another during this type, both the upstream and downstream trough are generally quite well marked. The latter trough may vary in position from Iceland to Europe; note the multiplicity of tracks in this area on figure 2.36. Jet stream activity north of the block is observed in all cases. Cyclonic jet stream activity is present south of the block in association with trapped lows. Large amplitude troughs downstream of the block result in jet stream occurrences as far south as the latitude of Spain. Some jet stream activity is observed in North Africa but not in appreciable amounts. Although the synoptic catalogue is small the cases selected seem characteristic when compared with those of the other seasons.

(3) Russia and Siberia

In western Russia, as in Europe, jet streams occur over a wide range of latitude. The jet stream configurations indicate two different synoptic regimes in this area - one a ridge of considerable amplitude which thrusts jet streams to a high latitude and the other, a trough system located in European Russia. Jet streams are largely absent in eastern Russia and Siberia due to the fact that these systems penetrate south of this area in association with a major low centered over eastern Siberia.

(4) Japan and the Pacific

Jet streams are concentrated primarily between the 35th and 45th parallels in the western Pacific and between the 40th and 55th parallels in the eastern Pacific. Three distinct patterns are evident during this type. In one pattern a broad trough in the western Pacific and a ridge in the Gulf of Alaska are the dominant features. A second pattern is characterized by a trough-ridge-trough configuration. In this case the ridge is located over the Aleutian Islands. Under this latter circumstance jet streams become reestablished south of the block and proceed across the Pacific in more or less zonal fashion. In the third pattern a broad trough is located over both the Aleutian Islands and the Gulf of Alaska. Zonal jet stream orientations are observed over nearly the entire Pacific with only slight cyclonic deformations in the vicinity of troughs.

2.5.2 Sub-Icelandic Block

(a) Location: 45°N-65°N; 35°W-5°W

The block area covers the eastern North Atlantic from the southeast coast of Greenland to England (fig. 2.37). It extends northward from the southern coast of England to Iceland.

(b) Regional Description

(1) North America

Jet stream occurrence is confined principally to the United States and southern Canada. In general, the configurations re-

flect the intrusion of cold air outbreaks from western Canada into the eastern United States. Two typical patterns are observed. The most common one is typified by the occurrence of a well developed trough or cut-off cold low in the western United States, ridging in the central portion and a very deep trough near Newfoundland. A second dominant pattern is characterized by ridging in the western United States and troughing in the eastern United States. Jet streams are observed in northern Canada in association with cyclonic systems along the rim of the Arctic. While they do not appear in great number at the 500 mb level they may be more frequent at higher altitudes.

(2) Altantic and Europe

Due to the presence of the block area in this sector, jet stream incidence is found over a wide range of latitudes with no pronounced zone of concentration. The area of incidence is particularly wide in the western Atlantic and Europe, indicating a great variation in the location and amplitude of the upstream and downstream trough throughout the sample.

In the Atlantic region the upstream trough varies in location from the Atlantic seaboard to the western Atlantic. The most common location, however, is near Newfoundland. Jet streams are observed along the northern periphery of the block in all cases. Jet stream activity to the south of the block, at least at the 500 mb level, is rather infrequent and occurs in association with trapped low centers.

In Europe the jet stream configurations indicate the presence of a well developed trough in Europe or Russia. An interesting facet is the tendency for a marked divergence of the jet stream tracks near the northeastern portion of the block area. One track continues across Russia at high latitudes while the other plunges southward in response to the downstream trough. Jet streams are observed in North Africa but the incidence is not high.

(3) Russia and Siberia

This region is characterized by jet stream configurations indicating the aforementioned deep trough in European Russia, weak ridging in central Russia and a deep trough near Japan.

Jet streams are also present along the rim of the Arctic in several cases. By and large the major incidence of jet streams is concentrated north of the 50th parallel across most of Russia, though shifting to the south of this parallel in Siberia.

(4) Japan and the Pacific

Jet streams occur over a fairly wide span of latitudes, particularly in the eastern Pacific. Two distinct areas of incidence are noted near Japan in the majority of cases, reflecting the intrusion and penetration of jet streams from both Siberia and southern China, respectively. These two jet stream systems continue into the central Pacific as separate entities. Although the jet stream configurations indicate the presence of troughing near Japan in virtually all of the cases, the synoptic patterns in the central and eastern Pacific are much more varied. For example, on those occasions when cold air penetrations from Siberia progress across the Pacific, the jet streams exhibit a zonal pattern over most of the ocean prior to ridging in the Gulf of Alaska or along the west coast of North America. On the other hand weak ridging may be present just off Japan or in the central Pacific. In any event two distinct tracks are usually evident.

2.5.3 North Sea - Scandinavia Block

(a) Location: 50°N-70°N; 5°W-25°E

The block area lies over the North Sea, northern Europe and the Scandinavian countries (fig. 2.38). It extends northward from Europe to the Barents Sea.

(b) Regional Description

(1) North America

There is a wide latitudinal variation in the distribution of jet streams over North America but the major concentration is found in central and southern Canada. Several distinct pressure patterns are noted with two separate jet streams being evident in each. One typical pattern shows high latitude jet stream activity associated with broadscale ridging in central Canada and a lower latitude jet stream activity in association with pronounced trough-

ing in the United States. A second pattern is somewhat similar to the foregoing but does not evidence any low latitude troughing. Another dominant pattern is characterized by jet stream activity around a trough configuration in the western United States in addition to jet stream systems near the Canadian border. In the majority of cases jet streams are not observed around the rim of the Arctic.

(2) Atlantic and Europe

The greater portion of the Atlantic just upstream of the block area is characterized by frequent occurrences of jet streams at rather low latitudes, accompanying deep penetrations of cold air. Although the degree of penetration varies considerably, the pressure pattern exhibits a well marked omega-type trough-ridge-trough configuration. The location of the cold air outbreak varies from Newfoundland to the central Atlantic. Marked jet stream activity is observed along the northern periphery of the block area in every case. Jet streams penetrate to the south of the block and may either exhibit a decided cyclonic configuration or a more zonal orientation. During some cases when lows are trapped south of the block, jet streams are thrust into North Africa.

(3) Russia and Siberia

The downstream trough of the blocking system lies over Russia. There is a great variation in trough amplitude as evident in the latitudinal span of the area of major incidence on figure 2.38. In cases of exceptionally large amplitude, single jet stream systems are evident in the eastern Mediterranean - Black Sea area. With troughs of more moderate amplitudes, two distinct jet stream systems are evident - one around the base of the trough near the Black Sea and a second in the Mediterranean. East of the Urals the major jet stream incidence is found between the 45th and 60th parallels. Although a great variety of configurations are apparent, weak ridging in central Russia seems to be the most common pattern. On certain occasions jet stream activity may be prominent near the Arctic rim but jet stream activity is largely absent in eastern Siberia.

(4) Japan and the Pacific

A well marked trough configuration is apparent near Japan in every case. Across the Pacific, however, two configurations may be noted. One typical pattern consists of a more or less zonal flow across the entire Pacific. A second common pattern shows a zonal flow which culminates in a ridge in the eastern Pacific. In either case two jet stream systems extending from Japan to the eastern Pacific are quite common. The greatest incidence of jet stream activity occurs between 35°N and 45°N in the western Pacific and between 40°N and 55°N latitude in the eastern Pacific.

2.5.4 European Russia Block

(a) Location: 50°N-70°N; 25°E-60°E

The block area extends eastward from Poland to the Ural mountains and northward from the Ukraine to the Barents Sea (fig. 2.39).

(b) Regional Description

(1) North America

Major jet stream activity over North America is centered in the United States with a secondary area of incidence in the Canadian Arctic. Two distinct configurations are prevalent. One pattern is delineated by weak ridging in the western United States, although the degree of development of this pressure pattern varies considerably from case to case. A second important configuration is characterized by strong trough development in the southwest United States and ridging along the East Coast. Generally, jet stream activity is mostly absent in Canada, particularly in the Hudson Bay area. Such jet stream activity as does occur is usually associated with cyclonic activity in Alaska.

(2) Atlantic and Europe

A variety of jet stream configurations are noted in this region. One such configuration indicates a trough just south of Newfoundland, ridging just east of Greenland, and a trough over Europe just upstream of the block area. The ridging in the central Atlantic may even acquire an amplitude equaling that of the block. Another jet stream configuration shows a trough centered off the United States with ridging in the east Atlantic being weak or absent.

A third jet stream configuration exhibits a weak ridge near the United States. In these latter cases the trough immediately upstream of the block is quite well marked.

(3) Russia and Siberia

Jet streams in Russia progress over the northern periphery of the blocking system in nearly all cases. Under conditions of blocking in extreme northerly latitudes, jet streams penetrate south of the block. Quite often the downstream trough possesses a large amplitude and pronounced meridional jet stream configurations result. In the majority of cases, jet stream activity continues in evidence across central Siberia, between the 40th and 50th parallels, shifting to the south of the well developed low in eastern Siberia. Jet streams are absent in northern Siberia.

(4) Japan and the Pacific

Due to the strong development of a major trough near Japan, the greater portion of jet stream incidence in the western Pacific is found in the lower middle latitudes. The location of this major trough, however, may vary from the longitude of Korea to the central Pacific. Cyclonic deformations predominate and in some cases two jet stream systems are clearly evident. Downstream, the synoptic patterns vary considerably, ranging from zonal flow across the entire Pacific to ridging in the central or eastern Pacific.

2.5.5 Ural Block

(a) Location: 55°N-75°N; 60°E-105°E

The block area lies over the West Siberian Lowlands being bounded by the Ural Mountains to the west and central Siberia Uplands to the east (fig. 2.40). It extends poleward from the northern periphery of the Mongolian Plateau to the Kara and Laptev Seas.

(b) Regional Description

(1) North America

Major jet stream incidence is centered in the northern United

States, particularly in the Great Lakes region. Three distinct jet stream configurations are apparent. The most typical pattern is characterized by a ridge in the western United States and a well defined trough in the eastern United States. The second type of pattern shows a trough near the Pacific, a large amplitude ridge over Hudson Bay and a trough over northeast United States. The third jet stream pattern is highlighted by a ridge in the Gulf of Alaska and a broad trough over most of Canada. Extensive zonal jet stream configurations are observed along the Canadian border.

(2) Atlantic and Europe

Most of the jet stream activity across the Atlantic is centered between the 45th and 60th parallels. In general the configurations reflect the presence of a ridge in the central or eastern Atlantic and a well developed trough in Europe or eastern Russia. As a rule jet streams are not observed in latitudes north of the 65th parallel over most of this sector.

(3) Russia and Siberia

Jet stream configurations in this area are responsive to the location and amplitude of the blocking activity in this area. In those cases where blocking activity is located in the western portion of the blocking area, the jet stream configurations clearly describe the downstream trough in Siberia. In those cases of blocking activity in the eastern portion of the blocking area, jet stream activity on the downstream side of the block tends to remain at high latitudes. By and large, jet stream occurrence is at a minimum in eastern Siberia.

(4) Japan and the Pacific

Jet stream configurations are more or less zonally oriented from Japan to the Gulf of Alaska. Most of the incidence is centered between the 40th and 50th parallels. In most of the case histories, the jet stream pressure pattern is characterized by pronounced ridging in the Gulf of Alaska or along the west coast of North America. In another significant pattern, a trough in the Gulf of Alaska becomes the characteristic feature. In both of these cases the "key" block is located in the eastern portion of the block area and jet stream activity is observed in eastern

Siberia and Alaska. Double jet stream systems, especially in the vicinity of Japan and around the bases of troughs in the Pacific, are clearly indicated in a number of cases in the catalogue.

2.5.6 Kamchatka - Western Alaska Block

(a) Location: 55°N-75°N; 165°E-150°W

The block area is centered over the Bering Straits (fig. 2.41). It extends eastward from Kamchatka to the Alaskan Range and northward from the Bering Sea to the Chuckee Sea.

(b) Regional Description

(1) North America

The wide distribution of jet stream incidence in this region on figure 2.41 reflects the variability in location and amplitude of the trough downstream of the key block. When the downstream trough is located in western or central North America, a double jet stream system is observed - one stemming from a trajectory north of the block and the second penetrating into the United States from a path south of the block. If the downstream trough is located in the Gulf of Alaska, jet stream incidence is centered along the Canadian-American border and consists of a series of short amplitude ridges and troughs. When the center of the blocking activity is located along the eastern portion of the blocking area the downstream trough shifts into eastern North America. Pronounced ridging is apparent in the central United States.

(2) Atlantic and Europe

Jet stream activity is restricted to the middle latitudes. Three distinct jet stream configurations are indicated. One pattern is characterized by a series of small amplitude ridges and troughs across the Atlantic, culminating in a large amplitude trough in the England - North Sea area. A second pattern shows a trough in the western Atlantic and a weak ridge over Europe. The reverse of this pattern which indicates a well developed ridge in the western Atlantic and a deep trough just west of England is the third characteristic configuration. Few jet streams were observed south of the 40th parallel throughout the four cases.

(3) Russia and Siberia

Jet stream activity across Russia and central Siberia is ordinarily confined to high latitudes. Indeed, in this study, few jet streams were observed south of the 50th parallel. The jet stream configurations indicate that ridging is the characteristic pattern. Occasionally the ridge in central Siberia develops to such an extent that an upstream trough of large amplitude is formed, resulting in the appearance of jet stream activity near the Caspian Sea. The case histories used here clearly indicate the presence of a well marked trough in eastern Siberia. Jet stream activity in this area is displaced southward around the bases of these troughs. Double jet stream systems are observed in this area.

(4) Japan and the Pacific

Double jet stream systems are observed in the vicinity of the Japanese Islands and the western Pacific. Due to the high latitude of the blocking action, jet streams are in evidence both north and south of the block in all four cases. In general, the jet stream configurations south of the block continue in a more or less zonal fashion into the eastern Pacific. Marked troughing activity is present near the Gulf of Alaska.

2.5.7 East Central Pacific Block

(a) Location: 35°N-55°N; 165°W-145°W

The block area extends southward from the Alaskan Peninsula to a point midway between Alaska and the Hawaiian Islands (fig. 2.42).

(b) Regional Description

(1) North America

The majority of jet stream incidence is centered in the United States. In most instances the jet stream configurations indicate the presence of a trough in the western United States accompanied by a second trough just off Newfoundland. In some cases the trough immediately downstream of the block is located just off the west coast of the United States with a second trough near the Great Lakes area. Under this circumstance jet stream activity

is observed across the northern United States but, in addition, a second jet stream system is evident in western Canada. This latter system stems from the double jet stream system over the block itself. Jet stream systems are observed near the rim of the Arctic on some occasions but are generally absent in the Hudson Bay area.

(2) Atlantic and Europe

Jet stream activity is observed over a considerable span of latitude in the Atlantic, largely due to variations in amplitude rather than variations in pressure pattern. In some instances the jet stream configurations indicate troughing in the western Atlantic and ridging in the eastern Atlantic. Evidence of a trough near Spain just south or southeast of the ridge is not unusual. Double jet stream systems are evident across the Atlantic in most of the cases. Troughing is the most characteristic pattern over Europe, although the amplitude varies considerably.

(3) Russia and Siberia

By and large, the area between Europe and eastern Siberia is characterized by a trough-ridge-trough pressure configuration. Such differences between the case histories as exist stem primarily from the intensity of cold air injections. Jet streams were not observed in great numbers in these three case histories. In this one case considerable jet stream activity was apparent, though confined to latitudes north of the 50th parallel.

(4) Japan and the Pacific

Pronounced jet stream activity is apparent in the trough area near Japan. Jet stream configurations through the Pacific reflect the location and amplitude of the blocking action in the east central Pacific. When the blocking activity is centered in the northern extremity of the blocking area, the resultant upstream and downstream troughs are of appreciable amplitude and the jet streams in these areas evidence decided cyclonic configurations.

2.5.8 Pacific West Coast Block

(a) Location: 35°N-55°N; 145°W-125°W

The block area lies south of the Gulf of Alaska and immediately adjacent to that portion of the Pacific Coast between central California and British Columbia (fig. 2.43).

(b) Regional Description

(1) North America

The wide distribution of jet stream activity in this sector reflects the great variability in location and amplitude of the key block and its downstream trough. Jet stream incidence is greatest in the United States with a minimum of activity in central and eastern Canada. Three distinct patterns are evident in the case histories. In the majority of cases the trough downstream of the block is located in the western United States accompanied by ridging in the eastern United States. In a variant of this pattern, the downstream trough is located in the central United States. The trough-ridge configuration is readily evident however. In all these cases the amplitude of the downstream trough is quite large, resulting in rather extensive meridional jet streams. When the downstream trough is restricted to fairly high latitudes, the blocking activity is located in the northern extremity of the blocking area.

(2) Atlantic and Europe

Although jet streams are observed over a considerable span of latitudes due to a variety of pressure patterns, the greatest incidence is located between the 40th and 50th parallels. When the eastern Atlantic is characterized by pronounced ridging the amplitude of the trough just upstream is quite large, resulting in jet stream activity being thrust to fairly low latitudes. The downstream trough in Europe is also well developed. When the pressure pattern shows a trough of considerable amplitude in the eastern Atlantic, a ridge over Europe, and a trough over European Russia, a double jet stream system is evident over this sector.

(3) Russia and Siberia

Jet stream incidence is located north of the 40th parallel in this sector. The jet stream configurations in the case histories indicate that a trough in European Russia, a ridge in central

Siberia and a trough in eastern Siberia comprise the dominant pattern. Although the location of the ridge varies somewhat, it generally is located in central Siberia. A double jet stream system is not observed in Russia and central Siberia as a rule, but is a typical condition in the vicinity of the eastern Siberian trough.

(4) Japan and the Pacific

The distribution of jet stream incidence in the western Pacific is associated with the intensity and location of the persistent troughing in this area. In the eastern Pacific the location and amplitude of the blocking action exert the dominant influence. Generally the jet stream configurations indicate zonal flow across the western and central Pacific regions and pronounced anticyclonic deformations in the Gulf of Alaska. Double jet stream systems are frequently apparent upstream and downstream from the blocks. Jet stream systems do not completely penetrate south of the block in any of the case histories.

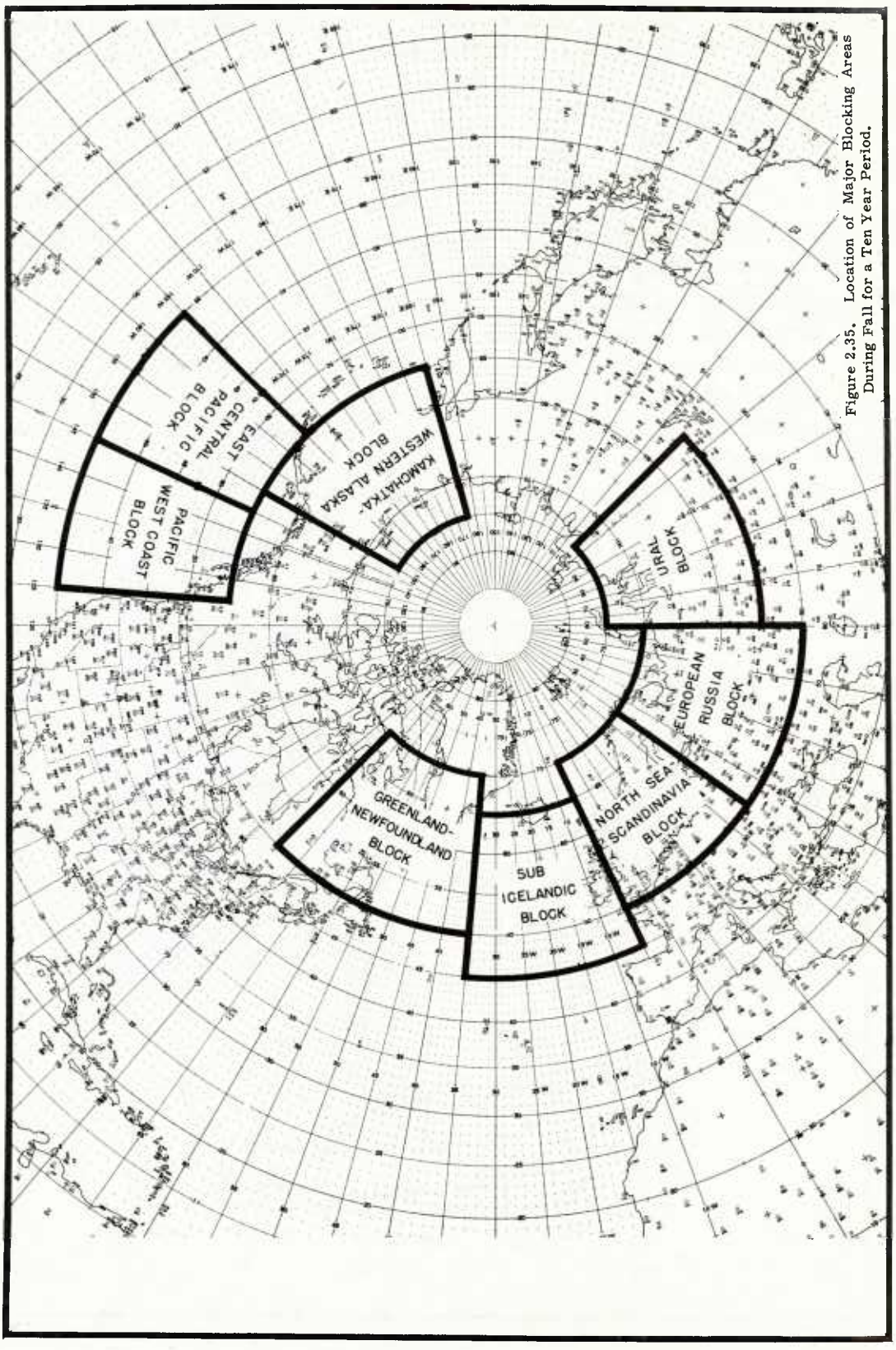

Figure 2.35. Location of Major Blocking Areas During Fall for a Ten Year Period.

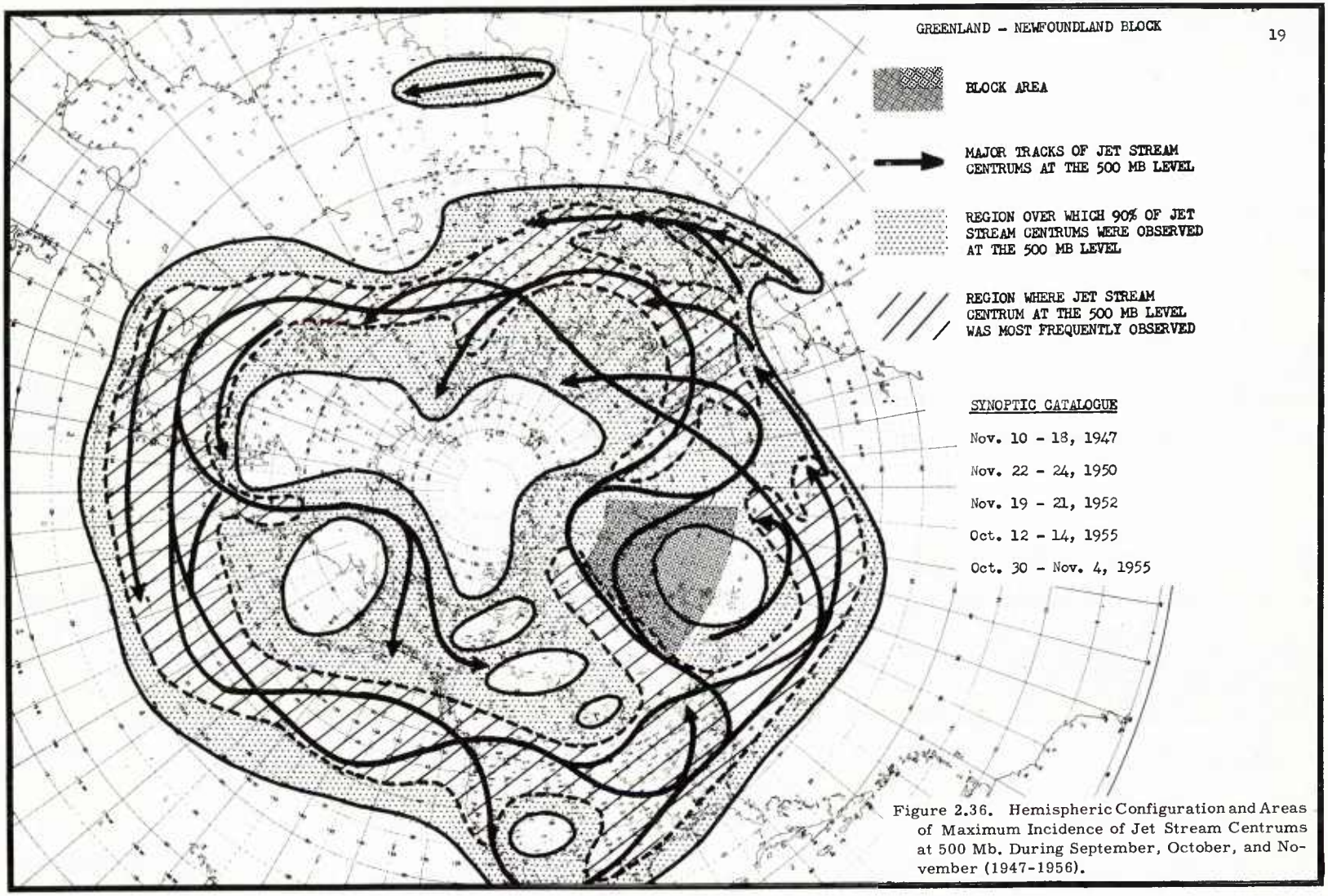

Figure 2.36. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

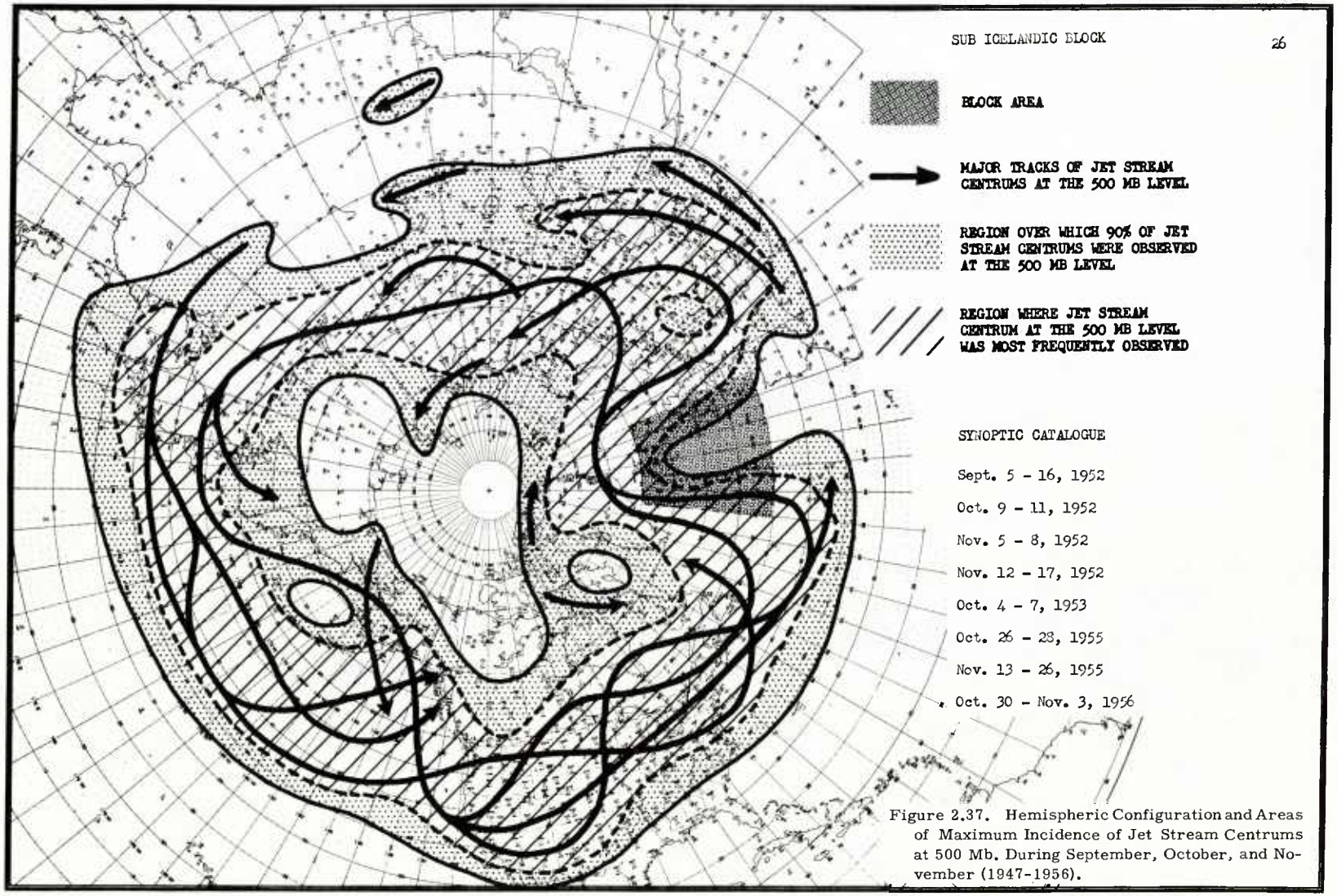

Figure 2.37. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

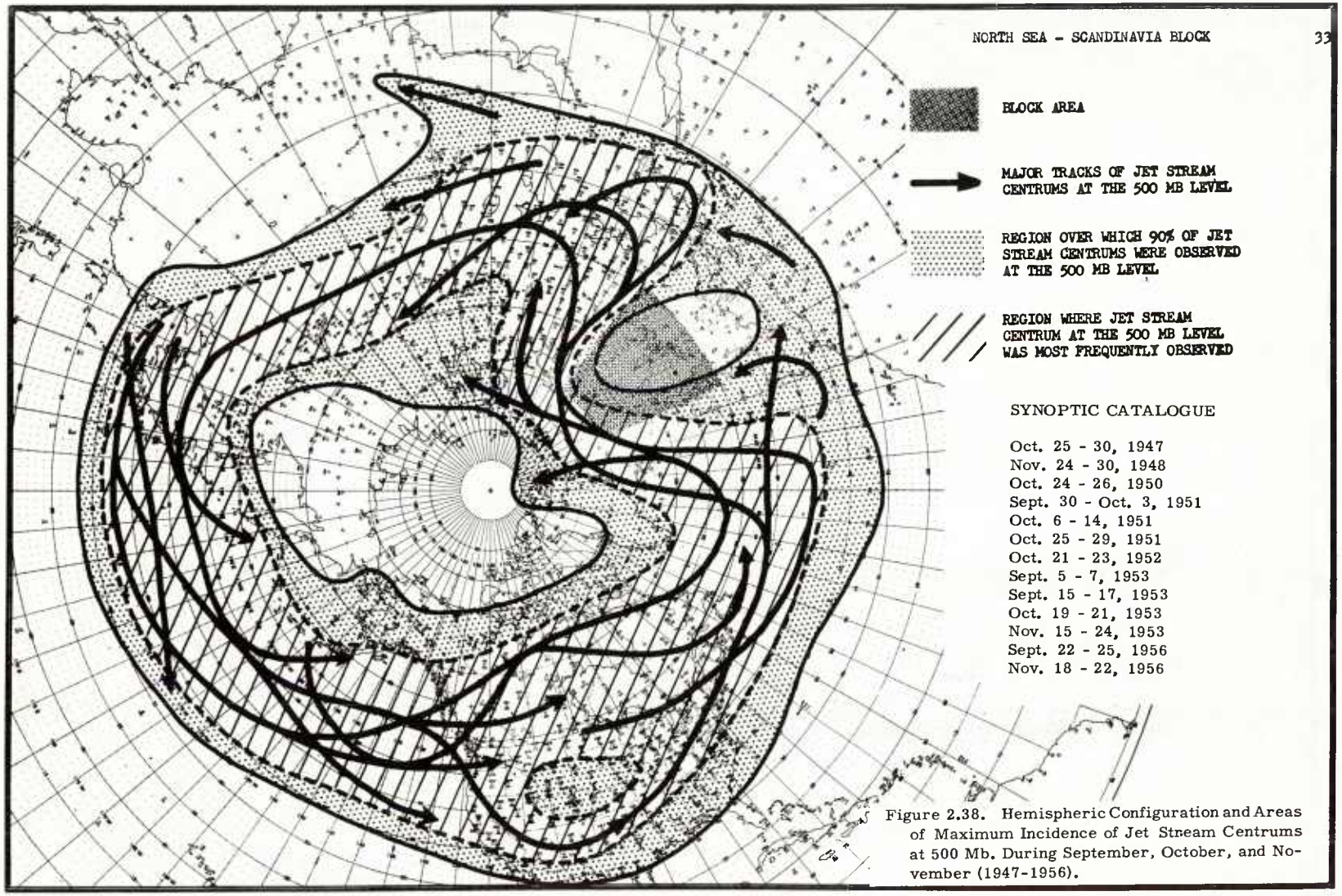

Figure 2.38. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

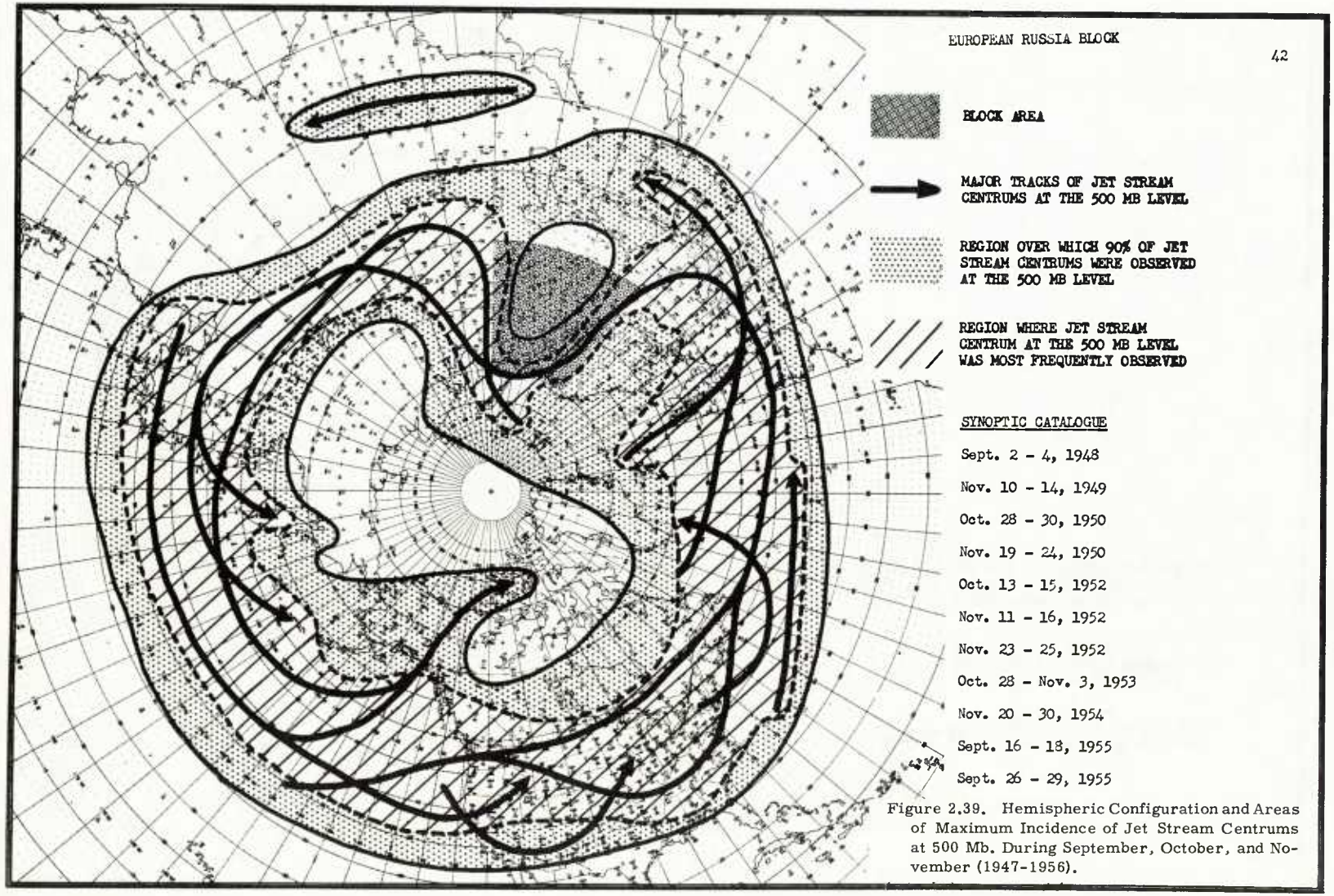

Figure 2.39. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

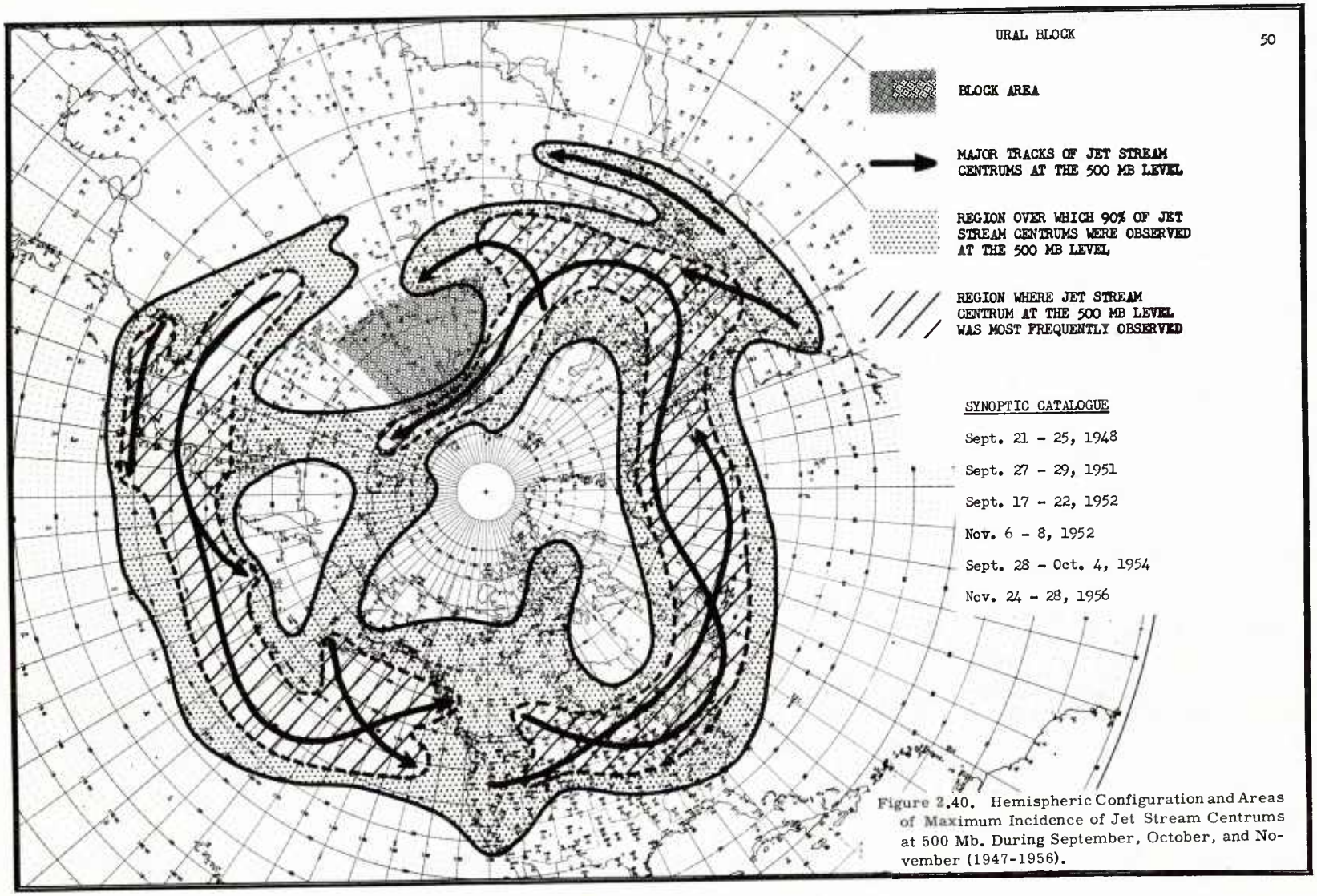

Figure 2.40. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

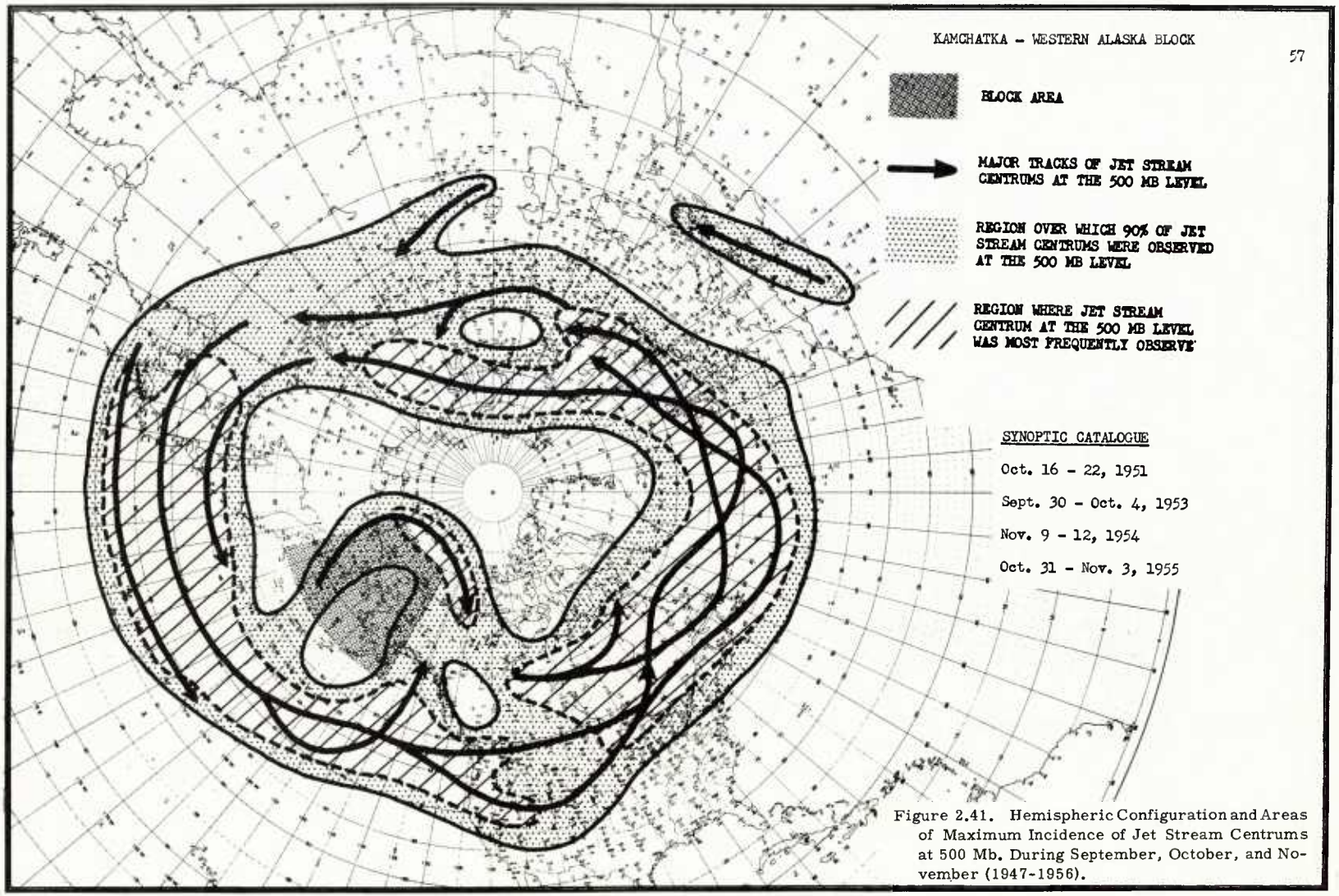

Figure 2.41. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

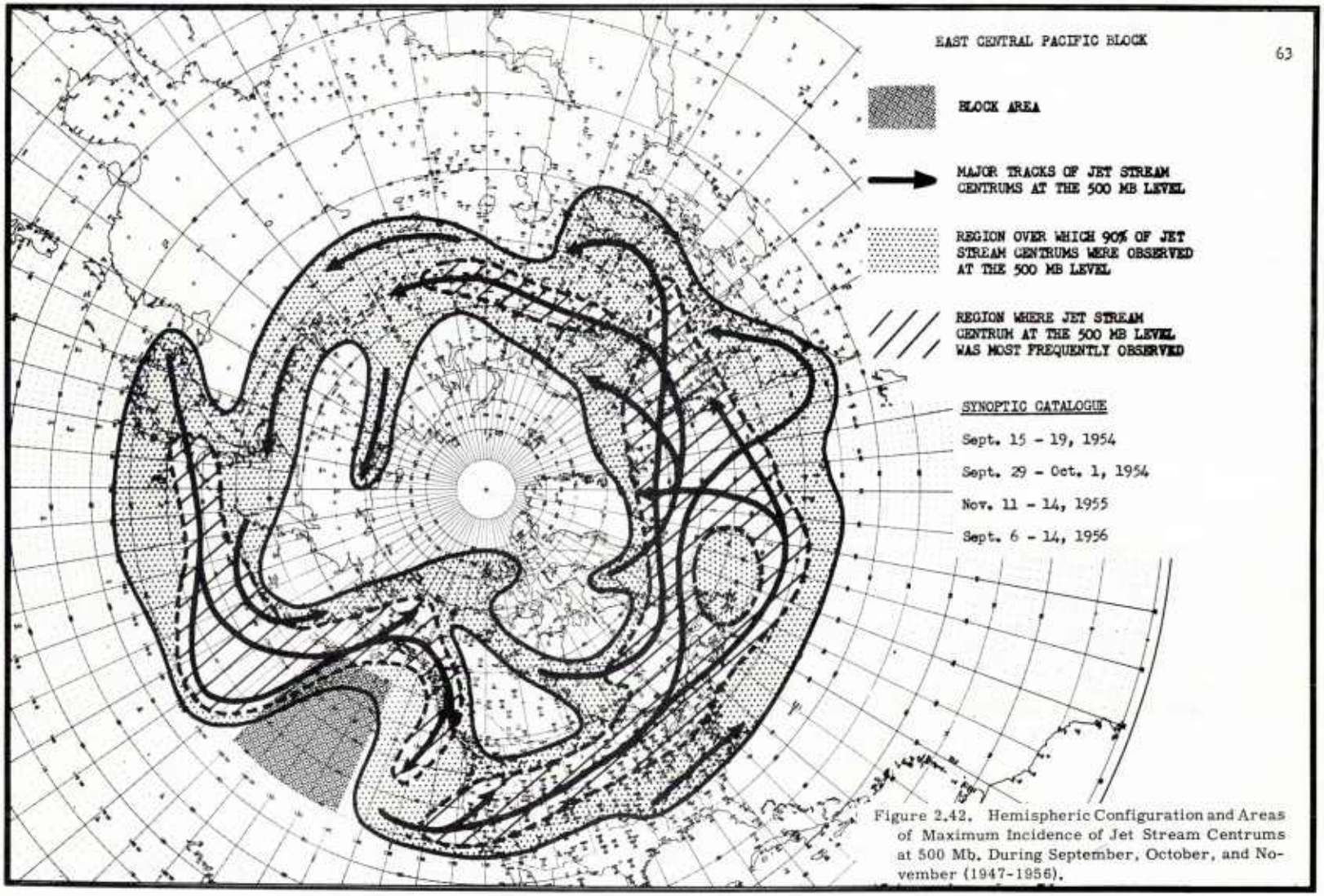

Figure 2.42. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

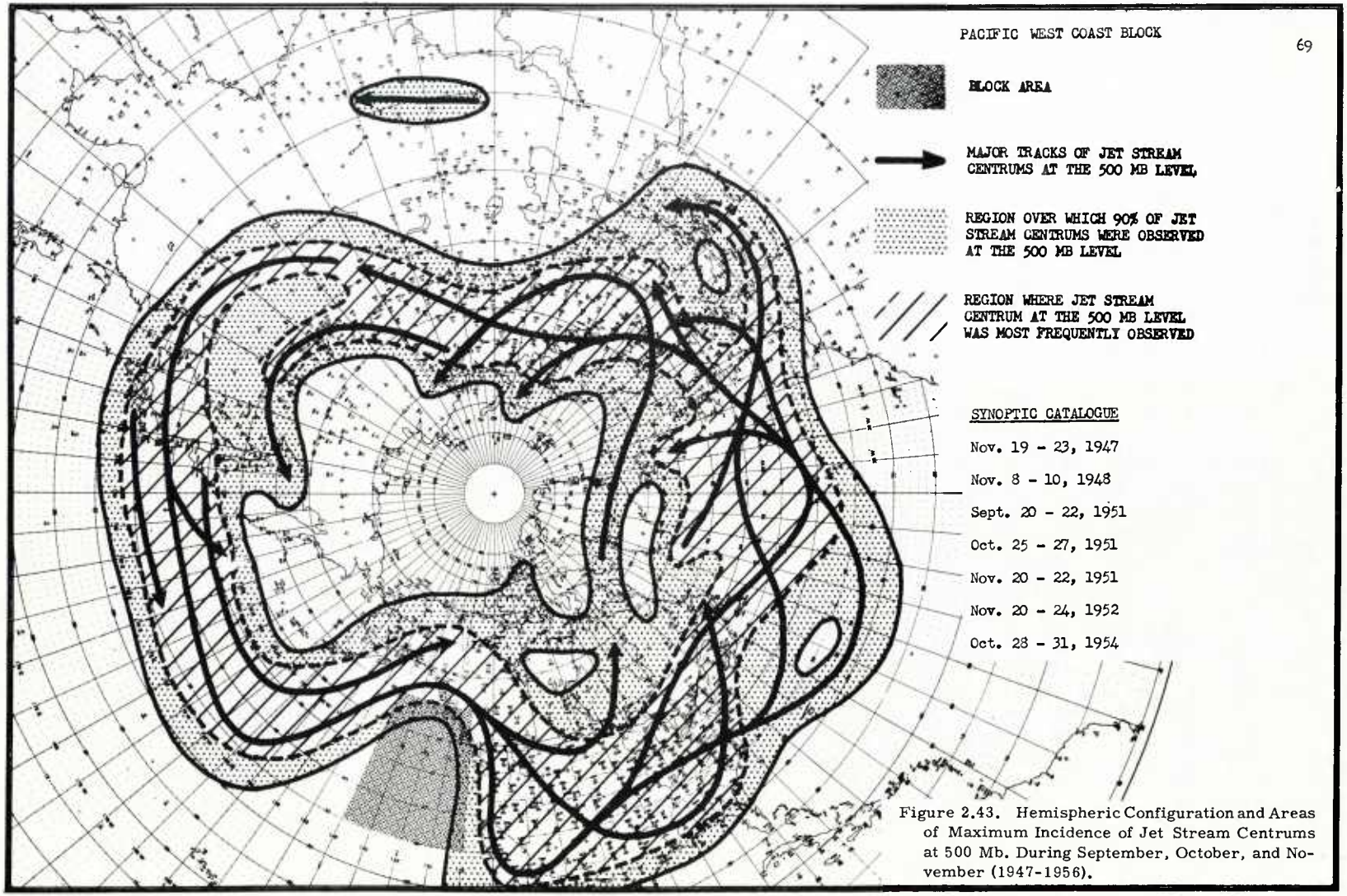

Figure 2.43. Hemispheric Configuration and Areas of Maximum Incidence of Jet Stream Centrums at 500 Mb. During September, October, and November (1947-1956).

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